

Addis Ababa University
School of Graduate Studies
Faculty of Technology

LOGIT MODEL OF WORK TRIP MODE
CHOICE
FOR
BOLE SUB- CITY RESIDENTS

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DECLARATION

I, the undersigned, declared that this thesis is my own work and has not been presented in any other university. All sources of material used for this thesis have been dully acknowledged.

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ABSTRACT

The issue of mode choice is probably the single most important element in transport planning and policy making. It affects the general efficiency with which we can travel in urban areas, the amount of urban space devoted to transport functions, and whether a range of choices is available to travelers (Juan De Dios Ortuzar, Luis G. Willumsen, 2004).

There are two transport studies undertaken for Addis Ababa which are part of the development and revision efforts of the Addis Ababa master plan. In both studies, the four stage travel demand model was adopted. However, the mode choice models developed in both studies are direct demand models which are basically based on aggregate data.

However, with present knowledge and computer technology, it is possible to model the mode choice for more than two alternatives by considering both the travel maker's and the travel mode's characteristics. Moreover, considering both socio-economic and travel mode variables will lead to a better understanding and simulation of the people's behavior in choosing among the competing modes. Therefore, in this research a Multinomial Logit model is developed, which is based on disaggregate socio economic, mode and trip related data, for work purpose trips made by Bole Sub-City residents.

The different modes of road passenger transport considered in the model are Walking, Small Taxis, Mini-Buses, Anbessa City Bus, Lonchina, Private vehicle as driver, Private vehicle as passenger and Company provided transport.

Among the various methods of revealed preference surveys, Household or Home Interview Survey was used as a data source in addition to secondary data obtained from different agencies of the city and this has been exploited to create the level of service data for the competing modes.

Finally different specifications of multinomial Logit models have been tested and it has been observed that the mode choice model has shown continuous improvement as explanatory power as it was enhanced from being restricted to mode related variables to incorporating the socio economic and trip related variables.

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Chapter 1

1. INTRODUCTION

1.1 General Overview

Transport Modeling is a simplified mathematical representation of a small part of the real world, aiming at describing and explaining travel behavior and visualizing the amount and patterns of transport. (Michel Bierlaire, 1997)

Traffic on road network can be calculated for the current situation and reliable estimation of traffic demand can be made for the future years using travel demand models taking as input land use, transport system, socio-economic characteristics of the population together with a mathematical approximation of human behavior.

The four stage demand model, popularly known as sequential travel demand model is one of the travel demand models in which the distribution of land use is represented in terms of population and employment allocation (urban transport study for Addis Ababa, 2005). This model is organized in four basic steps as shown in figure 1.1 and described below:

TRIP PRODUCTION AND ATTRACTION MODELS: This is the first stage in transport modeling and it converts the land use into trip production. In other words, based on data for land use, it calculates the number of trips produced and attracted to each zone in the study area.

TRIP DISTRIBUTION MODELS: These are used to relate the trip origins and destinations in the study area. At this stage we calculate the Origin–Destination (O-D) matrixes by using a measure of the spatial separation between origin and destination and our knowledge of how people react to this separation (distance, time, cost etc).

MODE CHOICE MODELS: Trips from an origin to a destination are distributed to the different modes of transport by using these models. This is the third step of the four stage transport modeling process and it simulates how people choose one mode of transport for their travel by using the characteristics of each mode and socio-economic variables.

ASSIGNMENT MODELS: are used to distribute car trips to the road network and public transport trips to the public transport network.

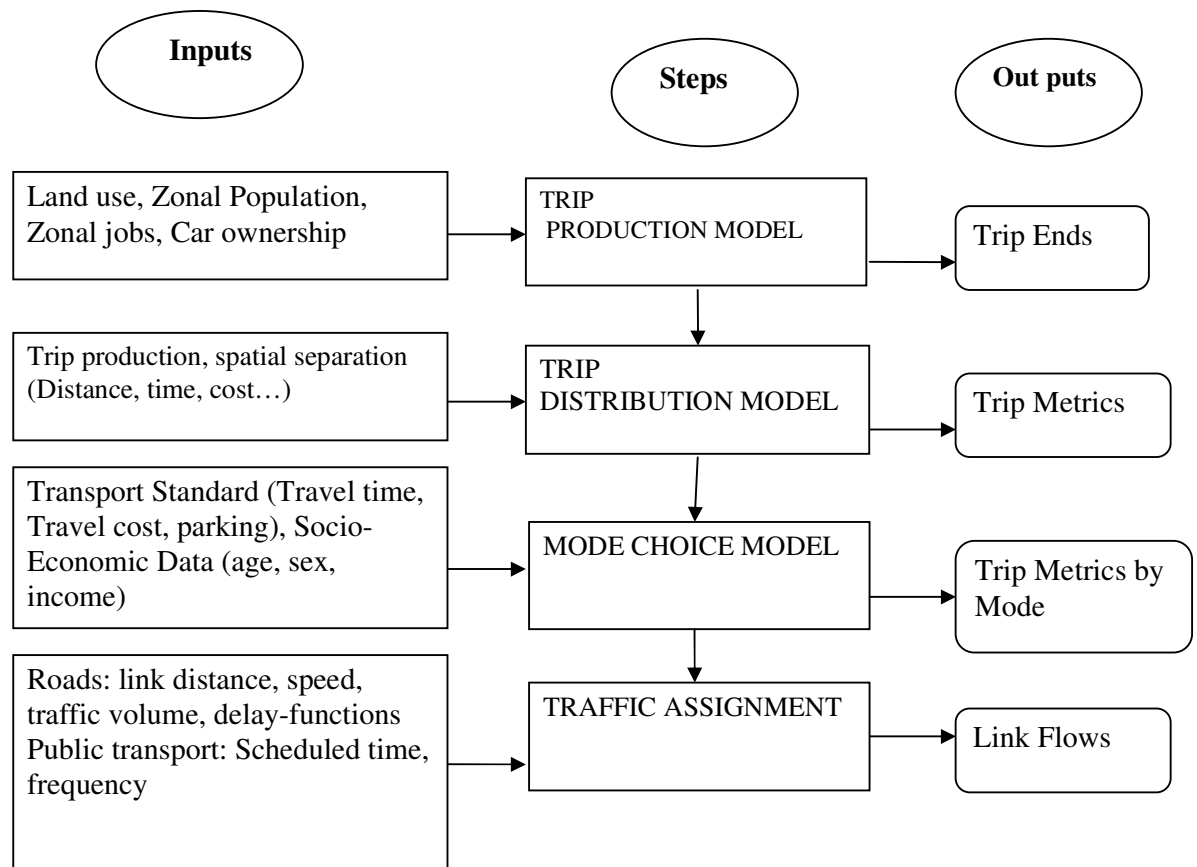


Figure 1.1: Sequential Travel Demand Modeling

1.2 Background of the Problem

The choice of transport mode is probably one of the most important classic models in transport planning. This is because of the key role played by public transport in policy making. Almost without exception public transport modes make use of road space more efficiently than the private car. Moreover, if some drivers could be persuaded to use public transport instead of cars, the rest of the car users would benefit from improved levels of service. It is unlikely that all car owners wishing to use their cars could be accommodated in urban areas without sacrificing large parts of the fabric to roads and parking space (Juan De Dios Ortuzar, Luis G. Willumsen, 2004).

The issue of mode choice, therefore, is probably the singlemost important element in transport planning and policy making. It affects the general efficiency with which we can travel in urban areas, the amount of urban space devoted to transport functions, and whether a range of choices is available to travelers. It is important then to develop and use models which are sensitive to those attributes of travel that influence individual choices of mode (Juan De Dios Ortuzar, Luis G. Willumsen, 2004).

1.3 Statement of the Problem

There are two transport studies undertaken for Addis Ababa which are part of the development and revision efforts of the Addis Ababa Master Plan. In both transport studies, the four stage travel demand model was adopted. However, the mode choice models developed in both studies are direct demand models which are basically based on aggregate data.

The first mode split model, which was developed by Torrieri Vincenzo, has first spited the pedestrian and motorized trips taking only travel distance as decision variable. Then the modal split within the private cars and the public transport was purely dependant on the traffic survey data.

With the assistance from the World Bank, The Ethiopian Roads Authority (ERA), Federal Democratic Republic of Ethiopia (FDRE), then undertook a second urban transport study for Addis Ababa city. In this study, the study team adopted a unique procedure of Modal Split. First a trip end model was developed to find the split between Walk and Vehicular trips which is completely dependent on use of the socio-economic characteristics of the traveler and trip purpose. Then within vehicular trips, modal split between private and public modes was also achieved using only income and purpose of trip variables. Finally, trip interchange model was used to arrive at modal split among the two competing modes in public transport (Anbessa Bus and Mini Bus). But, this trip interchange modeling approach facilitates the inclusion of characteristics of journey and the alternate modes available for making that journey but excludes the characteristics of trip maker.

However, with present knowledge and computer technology it is possible to model the mode choice for more than two alternatives by considering both the travel maker's and the travel

mode's characteristics. Besides, considering both socio-economic and travel mode variables will lead to a better understanding and simulation of the people's behavior in choosing among the competing modes. Therefore, the goal of this research is to develop a discrete choice model, which is based on disaggregate data, for work trips made by Bole Sub-City residents.

1.4 Research Objectives

The need to understand the travel behavior of people and to be able to model this behavior is increasingly important in order to ensure the adoption of the right policy for the benefit of the society and the economy of the country. The transport sector is one of the major consumers of the country's resources, but on the other hand the transport sector is also a very important base for stimulation of the economic development of a country.

This research will employ the Multinomial Logit Model to develop a mode choice model of work trips for Bole Sub-City residents. So this research has the objective of developing a complete mode choice model (specify, estimate and use) for Bole Sub-City residents. Although this thesis addresses problems in just one part of the city (i.e. Bole Sub-city), it is equally important to make the correct policy decisions with respect to the development of the city's transport system.

1.5 Significance of the Research

The main objective of this thesis is to develop mode choice model for work trips of Bole Sub-City residents. In addition to its application in transport modeling process as a travel demand forecasting tool, this mode choice model can be used in:

- I. the analysis of the probable market share of taxi and Anbessa Bus from Bole Sub-City area;
- II. the computation of modal choice elasticities; and
- III. the determination of time value for the Bole Sub-City residents

Thinking in a broader sense, since the attributes in the utility functions of each alternative must be policy relevant, the variables in the utility functions can be used as policy variables. Moreover, the model also gives information on the competition between the different modes. Thus, we can calculate the effect of different measures to improve the transport system.

Therefore, the developed mode choice model can be used as an input in the effort to predict future patronage levels for different scenarios; to understand passengers' preference to the different attributes of a public transport mode which could indicate how a new or improved mode would perform and to analyze policy variables relevant to the development of the transport system.

1.6 Scope and Organization of the Thesis

From ten Sub-Cities of Addis Ababa regional administration, only Bole Sub-City is Chosen randomly for this research. The major reason for this are limitation of time and financial constraint. Besides, out of the different purposes of travel, the research is delimited to the work purpose trips (Home to work trips). This is attributable to the share of work purpose trips among the different purpose trips in Addis Ababa. The urban transport and preparation of pilot project for Addis Ababa has predicted that the work purpose trips will constitute 36.19% out of all person trips in Addis Ababa by 2020 G.C (Urban Transport Study And Preparation Of Pilot Project For Addis Ababa, Final Report, 2005).

The first chapter of this paper gave a brief introduction of transport modeling and continued with the objectives and limitations of the research. Then, chapter two undertakes review of relevant literature. Chapter three discusses the specification of the model and chapter four gives a detailed description of the household survey and secondary data utilised for model development. Chapter five deals with the comparison of different alternative mode choice models developed and the selection of the optimal model. Finally, conclusions and recommendations are provided in chapter six.

Chapter 2

2. REVIEW OF RELATED LITERATURE

2.1 General Overview

A model, as a simplified description of the reality, provides a better *understanding* of complex systems. Moreover, it allows for obtaining *prediction* of future states of the considered system, *controlling* or *influencing* its behavior and *optimizing* its performances (Michel Bierlaire, 1997).

The complex system under consideration here is a specific aspect of human behavior dedicated to transport mode choice decisions. The complexity of this "system" clearly requires many simplifying assumptions in order to obtain operational models. A specific model will correspond to a specific set of assumptions, and it is important from a practical point of view to be aware of these assumptions when prediction, control or optimization is performed (Michel Bierlaire, 1997).

2.2 Factors Influencing the Choice of Transport Mode

The factors influencing mode choice may be classified into three groups and a good mode choice model should include the most important of these factors. These factors are presented in Juan De Dios Ortuzar, Luis G. Willumsen, (2004) as follows:

a) Characteristics of the trip maker.

The following features are generally believed to be important:

- Car availability and/or ownership;
- Possession of a driving license;
- Household structure (young couple, couple with children, retired, singles, etc.),
- Income;
- Decisions made elsewhere, for example the need to use a car at work, take children to school, etc;
- Residential density

b) Characteristics of the journey.

Mode choice is strongly influenced by:

- The trip purpose; for example, the journey to work is normally easier to undertake by public transport than other journeys because of its regularity and the adjustment possible in the long run;
- Time of the day when the journey is undertaken. Late trips are more difficult to accommodate by public transport.

c) Characteristics of the transport facility.

These can be divided into two categories. Firstly, quantitative factors such as:

- Relative travel time: in-vehicle, waiting and walking times by each mode;
- Relative monetary costs (fares, fuel and direct costs);
- Availability and cost of parking.

Secondly, qualitative factors which are less easy to measure, such as:

- Comfort and convenience;
- Reliability and regularity;
- Protection, security.

2.3 Direct Demand Models

There are quite a number of direct demand models but only trip end modal split model and trip interchange modal split model are included since they have been used in the development of mode choice models for Addis Ababa.

A trip end model allocates total person movements to alternate modes of travel before the trip distribution stage, whilst trip interchange models allocate movements to the alternate modes after the total movements have been distributed between zones of origin and destination (M.J Burton).

2.3.1 Trip-End Modal-Split Models

The application of mode choice models over the whole of the population results in trips split by mode. In the past, in particular in the, USA, personal characteristics were thought to be the

most important determinants of mode choice and therefore attempts were made to apply modal-split models immediately after trip generation. In this way, the different characteristics of the individuals could be preserved and used to estimate modal split: for example, the different groups after a category analysis model. As that level, there was no indication to where those trips might go, the characteristics of the journey and modes were omitted from these models (Juan De Dios Ortuzar, Luis G. Willumsen, 2004).

This was consistent with a general planning view that as income grew; most people would acquire cars and would want to use them. The objective of transport planning was to forecast this growth in demand for car trips so that investment could be planned to satisfy it. The modal-split models of this time related the choice of mode only to features like income, residential density and car ownership. In some cases the availability of reasonable public transport was included in the form of an accessibility index (Juan De Dios Ortuzar, Luis G. Willumsen, 2004).

In the short run, these models could be very accurate, in particular if public transport was available in a similar way throughout the study area and there was little congestion. However, this type of model is, to a large extent, defeatist in the sense of being insensitive to policy decisions; it appears that there is nothing the decision maker can do to influence the choice of mode. Improving public transport, restricting parking, charging for the use of roads, none of these would have any effect on modal split according to these trip-end models (Juan De Dios Ortuzar, Luis G. Willumsen, 2004).

2.3.2 Trip Interchange Modal-Split Models

Modal-split modeling in Europe was dominated, almost from the beginning, by post distribution models; that is, models applied after the gravity or other distribution model. This has the advantage of facilitating inclusion of the characteristics of the journey and that of the alternative modes available to undertake them. However, they make it more difficult to include the characteristics of the trip maker as they may have already been aggregated in the trip matrix (or matrices) (Juan De Dios Ortuzar, Luis G. Willumsen, 2004).

One important limitation of these models is that they can only be used for trip matrices of travelers who have a choice available to them. This often means the matrices of car-available persons, although modal split can also be applied to the choice between different public

transport modes (Juan De Dios Ortuzar, Luis G. Willumsen, 2004).

The models have little theoretical basis and therefore their forecasting ability must be in doubt. They also ignore a number of policy sensitive variables like fares, parking charges and so on. Further, as the models are aggregate they are unlikely to model correctly the constraints and the characteristics of the modes available to individual households (Juan De Dios Ortuzar, Luis G. Willumsen, 2004).

2.4 Discrete choice models

Aggregate demand (first-generation) transport models, such as trip-end and trip-interchange modal split models, are either based on observed relations for groups of travelers or on average relations at a zonal level. On the other hand, disaggregate demand (second-generation) models are based on observed choices made by individual travelers. It is expected that the use of this framework will enable more realistic models to be developed (Juan De Dios Ortuzar, Luis G. Willumsen, 2004).

In general discrete choice models postulate that:

The probability of individuals choosing a given option is a function of their socioeconomic characteristics and the relative attractiveness of the option (Michel Bierlaire, 1997).

Some useful properties of these models have been conveniently summarized by Juan De Dios Ortuzar, Luis G. Willumsen, (2004) as follows:

- i. Disaggregate demand models (DM) are based on theories of individual behavior and do not constitute physical analogies of any kind. Therefore, as an attempt is made to explain individual behavior, an important potential advantage over conventional models is that it is more likely that DM models are stable (or transferable) in time and space.
- ii. DM models are estimated using individual data and this has the following implications:
 - DM models may be more efficient than conventional models in terms of information usage; fewer data points are required as each individual choice is used as an observation. In aggregate modeling one observation is the average of (sometimes) hundreds of individual observations.
 - As individual data are used, all the inherent variability in the information can be

utilized.

- DM models may be applied, in principle, at any aggregation level; however, although this appears obvious, the aggregation processes are not trivial.
- DM models are less likely to suffer from biases due to correlation between aggregate units. A serious problem when aggregating information is that individual behavior may be hidden by unidentified characteristics associated to the zones; this is known as ecological correlation.

iii. Disaggregate models are probabilistic; furthermore, as they yield the probability of choosing each alternative and do not indicate which one is selected, use must be made of basic probability concepts such as:

- The expected number of people using a certain travel option equals the sum over each individual of the probabilities of choosing that alternative:

$$N = \sum_n p_{in}$$

- An independent set of decisions may be modeled separately considering each one as a conditional choice; then the resulting probabilities can be multiplied to yield joint probabilities for the set, such as in:

$$P(f, d, m, r) = P(f)P(d | f)P(m | d, f)P(r | m, d, f)$$

Where f = frequency; d = destination; m = mode; r = route.

iv. The explanatory variables included in the model can have explicitly estimated coefficients. In principle, the utility function allows any number and specification of the explanatory variables, as opposed to the case of the generalized cost function in conventional models which is generally limited and has several fixed parameters.

This has implications such as the following:

- DM models allow for a more flexible representation of the policy variables considered relevant for the study.
- The coefficients of the explanatory variables have a direct marginal utility interpretation (i.e. they reflect the relative importance of each attribute).

2.4.1 Random Utility Theory

The most common theoretical base framework or paradigm for generating discrete choice models is the random utility theory (Juan De Dios Ortuzar, Luis G. Willumsen, 2004), which basically postulates that:

- i. Individuals belong to a given homogeneous population \mathbf{Q} , act rationally and possess perfect information, i.e. they always select that option which maximizes their net personal utility (the species has even been identified as '*Homo economicus*') subject to legal, social, physical and/or budgetary (both in time and money terms) constraints.
- ii. There is a certain set $A = \{A_1, \dots, A_j, \dots, A_N\}$ of available alternatives and a set \mathbf{X} of vectors of measured attributes of the individuals and their alternatives. A given individual q is endowed with a set of attributes $x \in X$ and in general will face a choice set $A(q) \in A$.
- iii. Each option $A_j \in A$ has associated a net utility U_{jq} for individual q . The modeler, who is an observer of the system, does not possess complete information about all the elements considered by the individual making a choice; therefore, the modeler assumes that U_{jq} can be represented by two components:
 - A measurable, systematic or representative part V_{jq} which is a function of the measured attributes \mathbf{x} ; and
 - A random part ε_{jq} which reflects the idiosyncrasies and particular tastes of each individual, together with any measurement or observational errors made by the modeler.

Thus, the modeler postulates that:

$$U_{jq} = V_{jq} + \varepsilon_{jq}$$

Where: U = Utility; V = Measurable Part of Utility; ε = Random Part of Utility; j = alternative; and q = Individual

Which allows two apparent 'irrationalities' to be explained: that, two individuals with the same attributes and facing the same choice set may select different options, and that, some individuals may not always select the best alternative (from the point of view of the

attributes considered by the modeler).

For the decomposition U_{jq} to be correct we need certain homogeneity in the population under study. In principle we require that all individuals share the same set of alternatives and face the same constraints, and to achieve this we may need to segment the market.

Although, we have termed \mathbf{V} *representative* it carries the subscript q because it is a function of the attributes \mathbf{x} and this may vary from individual to individual. Also, without loss of generality it can be assumed that the residuals ε are random variables with mean 0 and a certain probability distribution to be specified.

$$V_{jq} = \sum_k \theta_{kj} x_{jkq}$$

Where the observed utility V_{jq} for individual q from alternative j is the sum of K parameters θ which are observed variables relating to alternative j (assumed to be constant for all individuals (fixed-coefficients model) but may vary across alternatives) and a vector of observed variables x_{jq} relating to individual q for each alternative j .

- iv. the individual q selects the alternative with maximum-utility U_{jq} , that is the individual selects the alternative A_j if and only if :

$$U_{jq} \geq U_{iq}, \forall \mathbf{A}_i \in \mathbf{A}(q)$$

In order to predict if an alternative will be chosen, according to the model, the value of its utility must be constrained with those of alternative options and transformed into a probability value between 0 and 1. For this, a variety of mathematical transformations exist which are typically characterized for having an S-shaped plot, such as: Logit and Probit (Juan De Dios Ortuzar, Luis G. Willumsen, 2004).

2.4.2 Logistic Probability Unit or Logit Model

The most widely used model in practical applications is probably the Logistic Probability Unit, or Logit, model (Michel Bierlaire, 1997). Its popularity is due to the fact that the

formula for the choice probabilities takes a closed form and is readily interpretable (Kenneth Train, 2003).

The Logit model is obtained by assuming that each ε_{nj} is independently identically distributed extreme value. The distribution is also called Gumbel and Type I extreme value (and sometimes, mistakenly, Weibull) (Kenneth Train, 2003).

The density for each unobserved component of utility is

$$f(\varepsilon_{nj}) = e^{-\varepsilon_{nj}} e^{-e^{-\varepsilon_{nj}}},$$

And the cumulative distribution is

$$F(\varepsilon_{nj}) = e^{-e^{-\varepsilon_{nj}}}$$

Where: ε = Random Part of Utility; j = alternative; and n = Individual

The variance of this distribution is $\pi^2/6$. The mean of the extreme value distribution is not zero; however, the mean is immaterial, since only differences in utility matter, and the difference between two random terms that have the same mean has itself a mean of zero (Kenneth Train, 2003).

The Gumbel distribution is an approximation of the Normal law, as shown in Figures 2.2, where the plain line represents the Normal distribution, and the dotted line the Gumbel distribution (Michel Bierlaire, 1997).

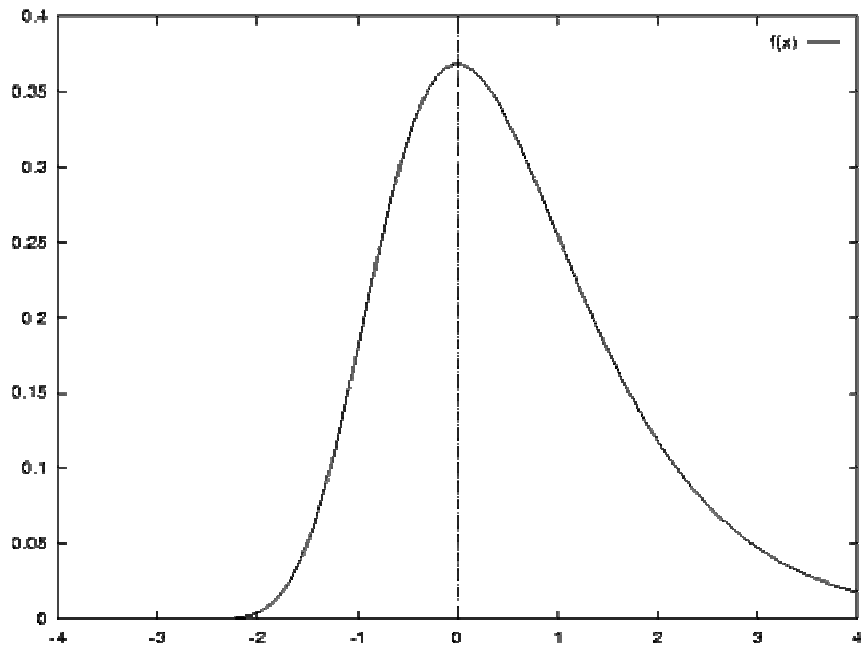


Figure 2.1: Gumbel distribution (Michel Bierlaire, 1997).

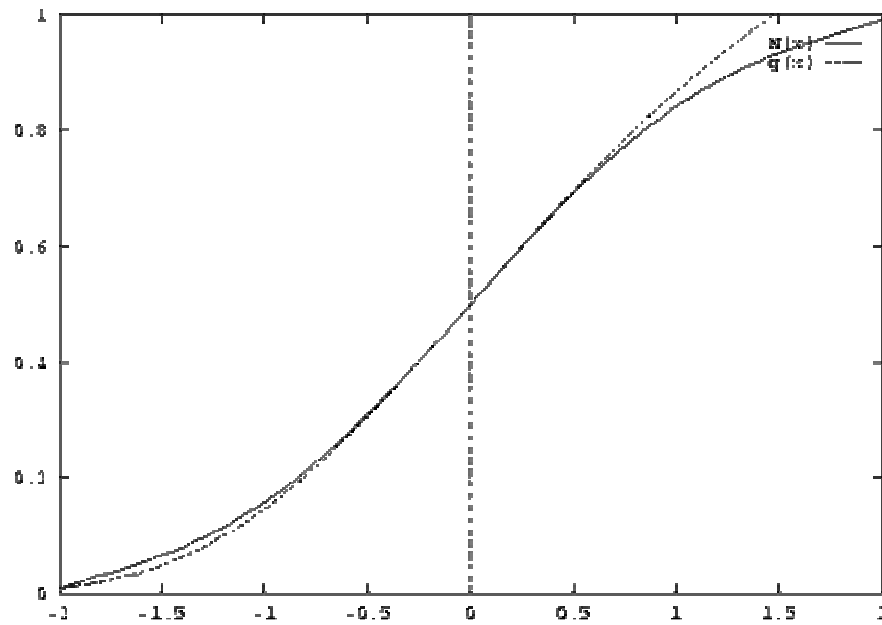


Figure 2.2: Comparison between Normal and Gumbel distribution (Michel Bierlaire, 1997).

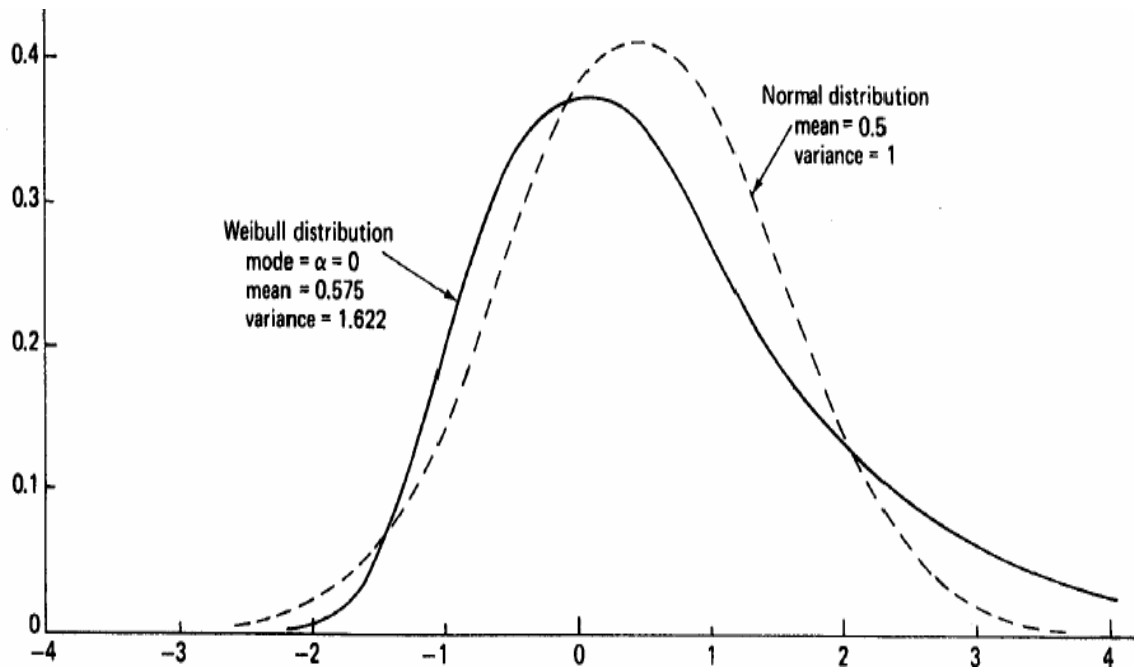


Figure 2.3: Frequency distribution of normal and Weibull distribution (Tom Domencich and Daniel L. Mcfadden, 1975)

Using the extreme value distribution for the errors (and hence the logistic distribution for the error differences) is nearly the same as assuming that the errors are independently normal. The extreme value distribution gives slightly fatter tails than a normal, which means that it allows for slightly more aberrant behavior than the normal. Usually, however, the difference between extreme value and independent normal errors is indistinguishable empirically (Kenneth Train, 2003).

The difference between two extreme value variables is distributed logistic. i.e, if ε_{nj} and ε_{ni} are independently identically distributed extreme value, then $\varepsilon_{nji}^* = \varepsilon_{nj} - \varepsilon_{ni}$ follows the logistic distribution

$$F(\varepsilon_{nji}^*) = \frac{e^{\varepsilon_{nji}^*}}{1 + e^{\varepsilon_{nji}^*}}$$

Where: ε = Random Part of Utility; j & i = alternatives; and n = Individual

This formula is sometimes used in describing binary Logit models, that is, models with two alternatives (Kenneth Train, 2003).

The key assumption is not so much the shape of the distribution as that the errors are independent of each other. This independence means that the unobserved portion of utility for one alternative is unrelated to the unobserved portion of utility for another alternative. It is a fairly restrictive assumption, and the development of other models such as Nested Logit and Probit has arisen largely for the purpose of avoiding this assumption and allowing for correlated errors (Kenneth Train, 2003).

It is important to realize that the independence assumption is not as restrictive as it might at first seem, and in fact can be interpreted as a natural outcome of a well-specified model. ε_{nj} is defined as the difference between the utility that the decision maker actually obtains, U_{nj} and the representation of utility that the researcher has developed using observed variables, V_{nj} . As such, ε_{nj} and its distribution depend on the researcher's specification of representative utility; it is not defined by the choice situation per se. In this light, the assumption of independence attains a different stature. Under independence, the error for one alternative provides no information to the researcher about the error for another alternative. Stated equivalently, the researcher has specified V_{nj} sufficiently that the remaining, unobserved portion of utility is essentially "white noise." In a deep sense, the ultimate goal of the researcher is to represent utility so well that the only remaining aspects constitute simply white noise; that is, the goal is to specify utility well enough that a Logit model is appropriate. Seen in this way, the Logit model is the ideal rather than a restriction (Kenneth Train, 2003).

2.4.3 Derivation of Logit Probabilities

The probability that decision maker n chooses alternative i is

$$\begin{aligned} P_{ni} &= \text{prob}(V_{ni} + \varepsilon_{ni} > V_{nj} + \varepsilon_{nj}) \forall j \neq i \\ &= \text{prob}(\varepsilon_{nj} - \varepsilon_{ni} > V_{ni} - V_{nj}) \forall j \neq i \end{aligned}$$

Where: V = Measurable Part of Utility; ε = Random Part of Utility; j & i = alternative; and n = Individual

If ε_{ni} is considered given, this expression is the cumulative distribution for each ε_{nj} evaluated at $\varepsilon_{ni} + V_{ni} - V_{nj}$, which is $\exp(-\exp(-(\varepsilon_{ni} + V_{ni} - V_{nj})))$ since ε 's are independent, this cumulative distribution over all $j \neq i$ is the product of the individual cumulative distributions:

$$P_{ni} \setminus \varepsilon_{ni} = \prod_{j \neq i} e^{-e^{-(\varepsilon_{ni} + V_{ni} - V_{nj})}}$$

Of course, ε_{ni} is not given, and so the choice probability is the integral of $P_{ni} \setminus \varepsilon_{ni}$ over all values of ε_{ni} weighted by its density:

$$P_{ni} = \int \left(\prod_{j \neq i} e^{-e^{-(\varepsilon_{ni} + V_{ni} - V_{nj})}} \right) e^{-\varepsilon_{nj}} e^{-e^{-\varepsilon_{ni}}} d\varepsilon_{ni}$$

Some algebraic manipulation of this integral result in a succinct, closed form expression:

$$P_{ni} = \frac{e^{V_{ni}}}{\sum_j e^{V_{nj}}}$$

Which is the Logit choice probability

Representative utility is usually specified to be linear in parameters:, $V_{nj} = \beta' x_{nj}$ where x_{nj} is a vector of observed variables relating to alternative j and β' is a vector of constants for each x_{nj} . With this specification, the Logit probabilities become

$$P_{ni} = \frac{e^{\beta' x_{ni}}}{\sum_j e^{\beta' x_{nj}}}$$

Under fairly general conditions, any function can be approximated arbitrarily closely by one that is linear in parameters. The assumption is therefore fairly benign. Importantly the log-likelihood function with these choice probabilities is globally concave in parameters β , which

helps in the numerical maximization procedures. Numerous computer packages contain routines for estimation of Logit models with linear-in-parameters representative utility (Kenneth Train, 2003).

2.4.4 Multinomial Logit model

As introduced in the previous section, the Logit model is derived from the assumption that the error terms of the utility functions are independent and identically Gumbel distributed. These models were first introduced in the context of binary choice models, where the logistic distribution is used to derive the probability. Their generalization to more than two alternatives is referred to as *multinomial* Logit models (Michel Bierlaire, 1997).

$$P_{ni} = \frac{e^{V_{ni}}}{\sum_j e^{V_{nj}}} = \frac{e^{\beta' x_{ni}}}{\sum_j e^{\beta' x_{nj}}}$$

2.5 Mode Split Models Developed For Addis Ababa

There are two mode choice models developed for Addis Ababa, which are part of the development of the master plan for the city. The first model is developed in March 1985 by Torrieri Vincenzo under the study mobility and traffic forecasting and the second model was developed in 2005 in the urban transport study for Addis Ababa under the study Urban Transport Study and Preparation of Pilot Project for Addis Ababa.

In both models walking was first splitted from Vehicular travel modes by using first generation mode split models taking distance as a determining factor in the first model and income in the second model. The splitting of the motorized trips into motor car and public transport modes was purely dependant on the availability of traffic survey data in the model of Torrieri while the recent model assumed the only determining factor in the choice between private and public transport modes is the economy and they have developed a model depicting the relation between household income and the share of private vehicle modes for various trip purposes. The fist model ended by dividing the motorized trips into motorized car and public transport but the second model has gone further developing a logit model for the two competing modes of public transport Minibus taxi and Anbessa bus by considering the

relative cost and service properties of trip and ignoring the socio-economic characteristics of the riders.

2.5.1 Mode Split Model Developed By Torrieri, Vincenzo (1985)

The transport demand forecasting model developed for Addis Ababa by Torrieri, Vincenzo had four sub models (Generation model, Distribution model, model split model and Assignment model).

The model split model, at first, splits between pedestrian and motorized mobility, by the following relation;

$$Y = a * \ln d + b$$

Where:

- Y is percentage of pedestrian for each trip from a certain origin to a certain destination and
- a, b are constant variable with trip purpose.

To perform the evaluation of constants a and b from survey data, the variable d was divided into d_1 and d_2 distances so that:

- If $d_{ij} \leq d_1$ all trips are pedestrian
- If $d_{ij} \geq d_2$ all trips are motorized

Where i and j are the origin and destination of trip respectively.

The model is then represented as

$$Y = 100 * \frac{\ln d_{ij}}{\ln(d_1 / d_2)} - 100 * \frac{\ln d_2}{\ln(d_1 / d_2)}$$

Where:

$$a = \frac{100}{\ln(d_1 / d_2)} \quad \text{And} \quad b = -100 * \frac{\ln d_2}{\ln(d_1 / d_2)}$$

Generally, the constants were reported to have the following values under different trip purposes:

- Home to Work $a = -95, b = + 56$

- Home to General a = -95, b = + 56
- Not Home Based a = -84, b = + 41
- Over All Mobility a = -89, b = +52

All motorized trips are then split between transport modes, according to the following table:-

Table 2.1: Modal split general figure

TRIP KIND	PURPOSE	TRANSPORT MODE	
		MOTOR CAR	PUBLIC TRANSPORT
A	Work General SS	% HTW % HTG % HTSS	% PTW % PTG % PTSS
B	Work General SS	identical	identical
C	Work General SS	identical	identical
D	Work General SS	identical	identical

The trip kind is correlated to Public Transport Accessibility (P.T.A) at the origin/destination zone so:

Kind-A: - Refers to trips between zones with low P.T.A at both trip ends.

Kind-B: - Refers to trips between zones with high P.T.A at one trip end.

Kind-C: -Refers to trips between zones with medium P.T.A at both trip ends.

Kind-D: -Refers to other trips

Where:

%HTW is percentage of Home to Work trips by motor car

%HTG is percentage of Home to General trips by motor car

%HTSS is percentage of Non Home Based trips by motor car

%PTW is percentage of Home to Work trips by public transport

%PTG is percentage of Home to General trips by public transport

%PTSS is percentage of Non Home Based trips by public transport

2.5.2 Modal Split Model Used In the Urban Transport Study for Addis Ababa, 2005

The Ethiopian Roads Authority (ERA), under assistance from the World Bank, has undertaken an urban transport study as a project entitled, “Urban Transport Study & Preparation of Pilot Project for Addis Ababa”. The study adopted a unique procedure of Modal Split. First mode split between walk and vehicle trips was determined using income levels. For this, the projected income levels for each of the traffic analysis zones in the city were used and the zone-wise trips by walk mode and by purpose were also estimated. The trip that ends by vehicular modes have been obtained by deducting the walk trip share from the total trip ends. Then modal split between private and public modes within the vehicular trips was determined by using the private mode share model, which uses income levels as the criteria for assessing the share of private modes in the total vehicular trips. The zone wise share of trips by private modes was estimated for work, education, other purpose and for non-home based trips separately by using this model. Finally, the choice of modes among Public Transport Modes was calculated using Logit Model approach. The two competing modes considered were Minibus and the Anbessa City-Bus. The following assumptions were used when applying the Logit Model:

- Average Access distance is 500m for both Minibus and Anbessa City-Bus
- Average Waiting time is 5minutes for both Minibus and Anbessa City-Bus and
- No change in fare system.

Using the procedure described above the study estimated the travel demand by different modes as:

- Walk Mode - 45% (this does not include Access walk trips)
- Vehicular Modes -55% i.e. 9% private modes and 46% public transport.

Taking a detailed look, study carried out modal split analysis in two stages:

- i. Pre-Distribution Stage (Trip End Modal Split Modeling) and
- ii. Post-Distribution Stage (Trip Interchange Modal Split Model).

At Pre-Distribution Stage, trip ends are modeled or obtained for each of the modes. At this stage, it is assumed that the major determinants of mode choice are socio-economic characteristics of trip makers. Trip characteristics of each trip maker, that influence the mode choice decisions at this stage are household income or vehicle ownership, family size & constitution, trip-purpose etc (Urban Transport Study And Preparation of Pilot Project For Addis Ababa, Final Report, December 2005).

At Post Distribution Stage, the trip matrix is split into different modes, based upon the generalized cost of using a particular mode. Here the model assumes that the major determinants of public transport patronage are the relative cost and service properties of trip by private and public transport. This emphasizes on the choice of riders and does not directly consider socio-economic characteristics of riders (Urban Transport Study And Preparation of Pilot Project For Addis Ababa, Final Report, December 2005).

In general, the study assumes that the first choice between walk and vehicular modes is influenced by the economic status of the household. Moreover, mathematical models were developed in order to assess the relationship between the choice of vehicular modes/walk and the economic status (i.e. income) of households. Figure 2.4-2.7 shows the variation of share of walk trips in relation to increases in monthly household income for various purposes of trips. These Figures show that with the increase in income, the tendency towards vehicular modes increases. Which, they have found to be more prominent in the case of work purpose trips. (Urban Transport Study And Preparation of Pilot Project For Addis Ababa, Final Report, December 2005).

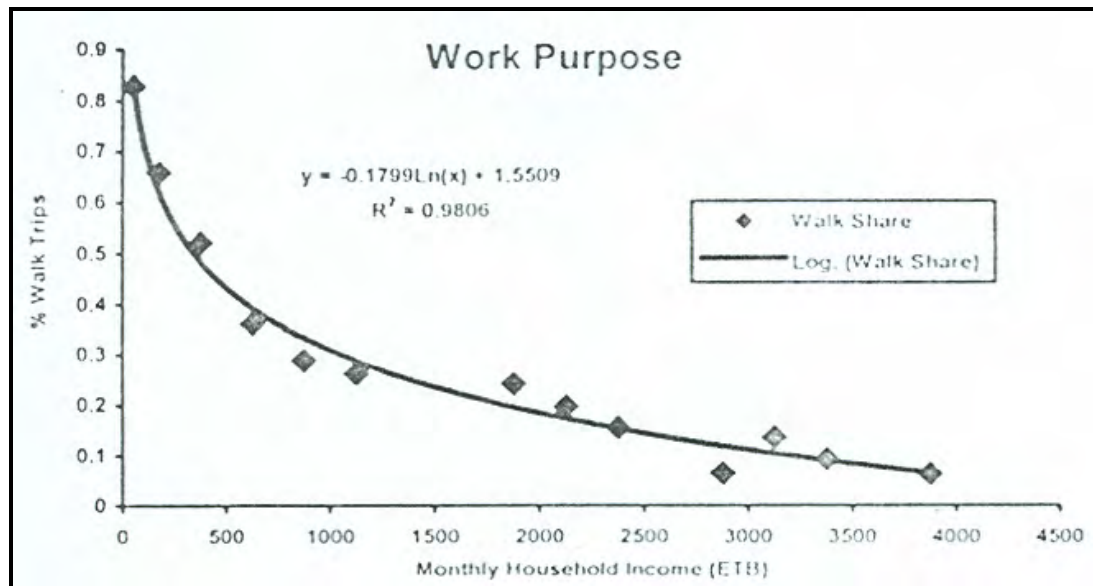


Fig 2.4 Share of Work Purpose Walk Trips with the Increase in Monthly Household Income

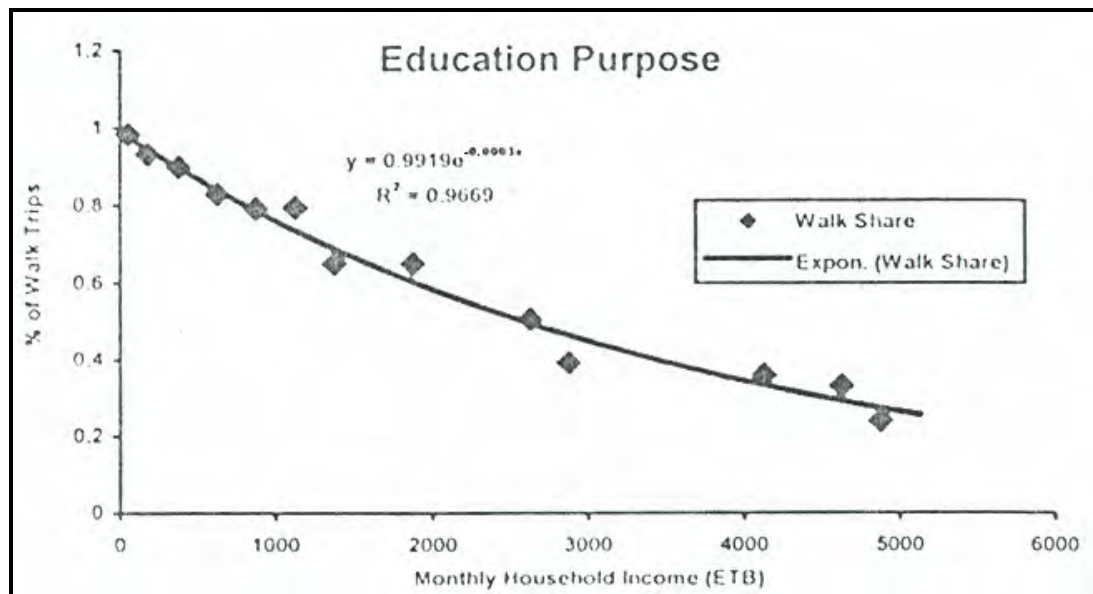


Fig 2.5 Share of Education Purpose Walk Trips with the Increase in Monthly Household Income

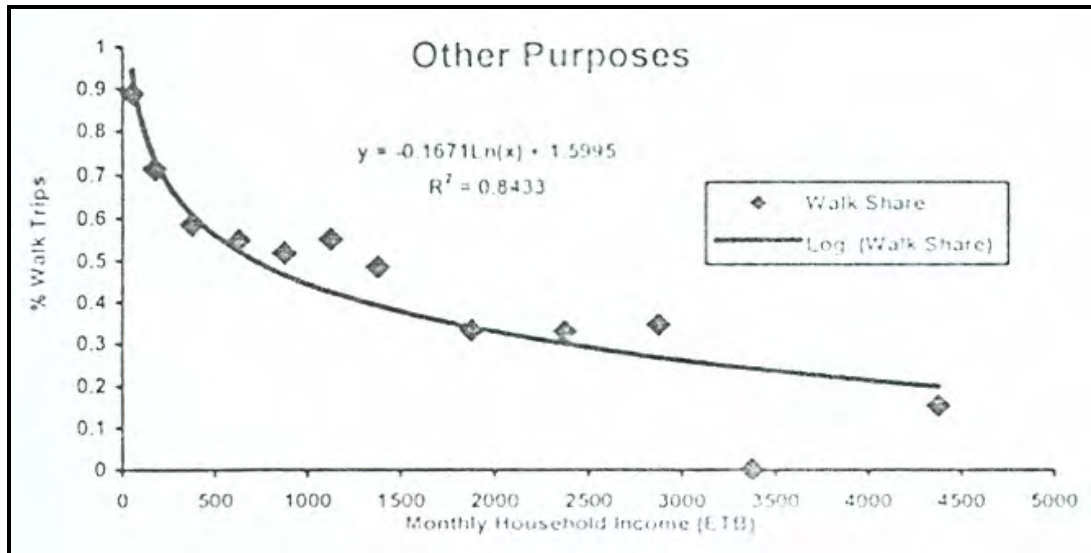


Fig 2.6 Share of Other Purpose Walk Trips with the Increase in Monthly Household Income

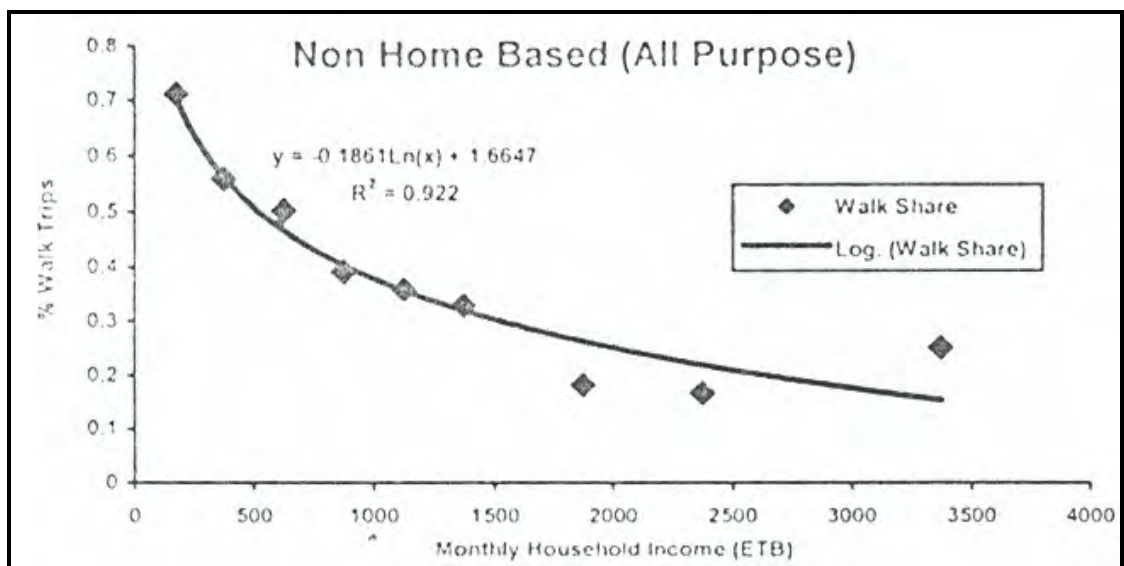


Fig 2.7 Share of Non Home Based All Purpose Walk Trips with the Increase in Monthly Household Income

Within the vehicular modes, the study assumes choice of using private modes is dependent upon the availability of a vehicle, which in turn is dependent upon the economic status of a given household. Analysis was undertaken upon the influence of income on the choice of mode in terms of the contribution private modes to the total vehicular trip in order to understand the dynamics of mode choices. Figure 2.8-2.11 shows the scatter diagram and the best-fit curve between the household income and share of private modes for various trip

purposes. It can be seen that as income increases the share of private vehicle trips increases. Also, the rate of change per unit change in income decreases. The relation that explains the share of private vehicle trips for work purpose has a power function. A linear relation has also been observed to explain the variation in the share of private vehicle trips with respect to income in case of education and other purpose trips and a power function in case of non-home based trips. (Urban Transport Study And Preparation of Pilot Project For Addis Ababa, Final Report, December 2005).

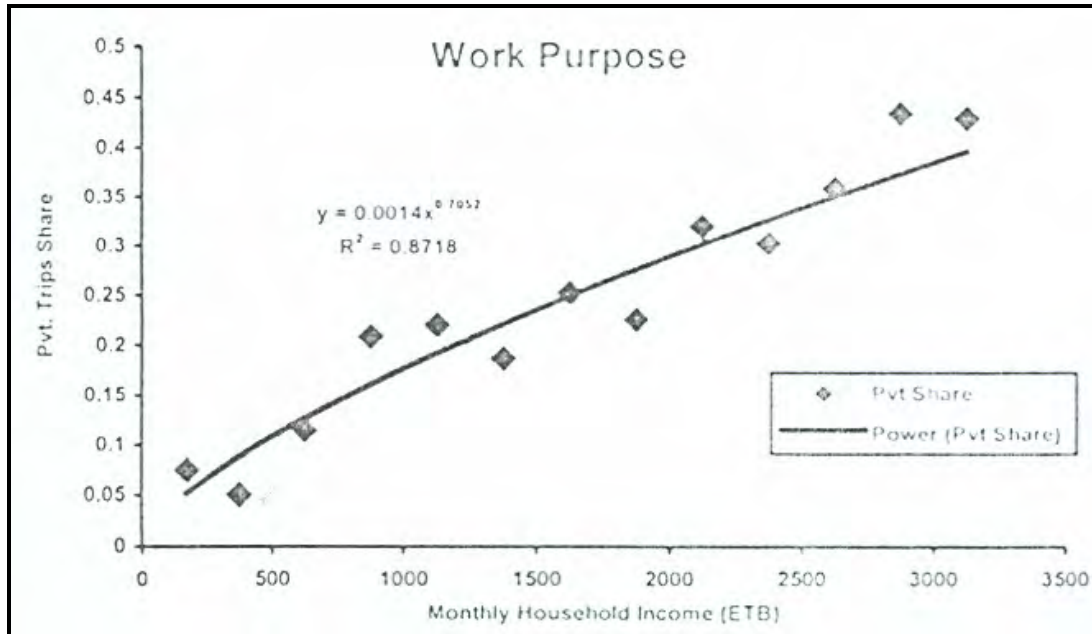


Fig 2.8 Scatter Diagram and the Best-Fit Curve Between Household Income and Share of Private Modes for Work Purposes Trip

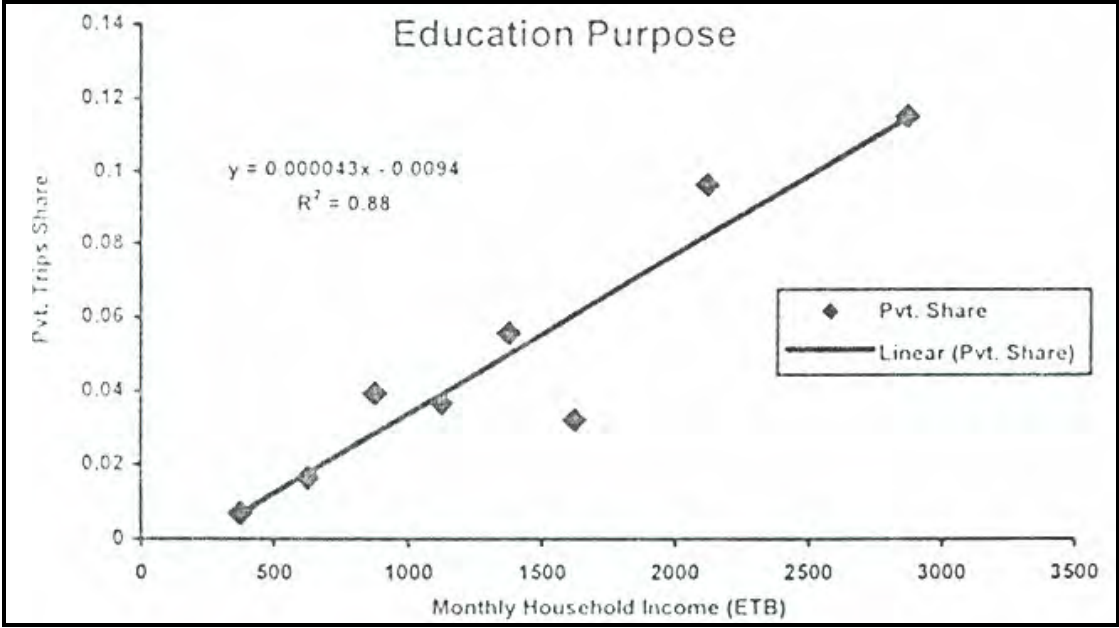


Fig 2.9 Scatter Diagram and the Best-Fit Curve between Household Income and Share of Private Modes for Education Purposes Trip

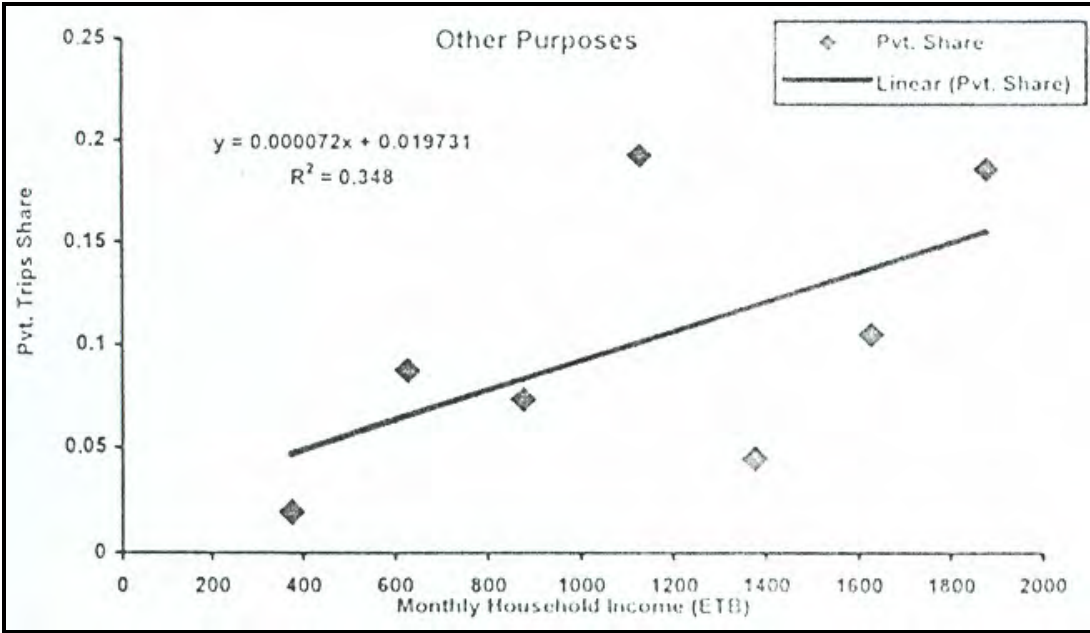


Fig 2.10 Scatter Diagram and the Best-Fit Curve Between Household Income and Share of Private Modes for Other Purposes Trip

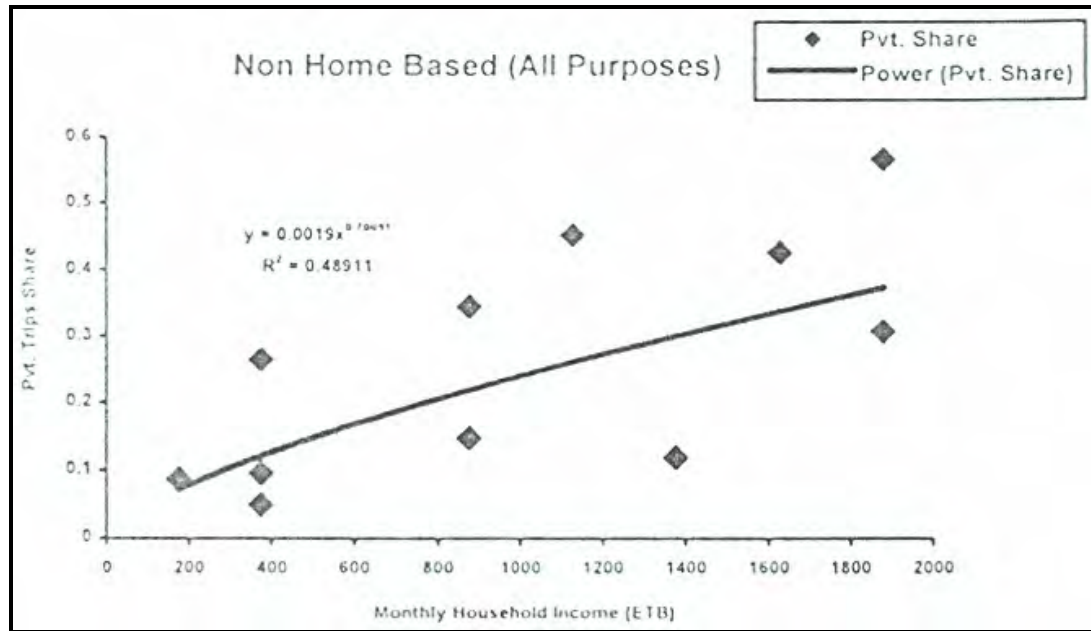


Fig 2.11 Scatter Diagram and the Best-Fit Curve between Household Income and Share of Private Modes For Non Home Based All Purposes Trip

For public transport users, the study considered two facilities, Namely, Anbessa Bus service and Minibus as available competing modes and a Logit model was developed in order to assess the choice behavior between Anbessa City Bus service and Minibus service based on the generalized cost of travel by these services. The generalized cost component includes in vehicle travel time, access time, waiting time, out-of-pocket cost, reliability, comfort and convenience etc. (Urban Transport Study And Preparation of Pilot Project For Addis Ababa, Final Report, December 2005).

The functional form of the Logit model developed by Consulting Engineers Services (India) in Association with Saba Engineering is as follows:

$$P1 = \frac{1}{1 + \exp\{-\lambda(C2 - C1)\}}$$

Where,

P1 - Probability of choosing Mode 1

C1 - Cost of Travel by Mode 1 (incl. access time, waiting time, cost of travel etc)

C2 - Cost of Travel by Mode 2 (incl. access time, waiting time, cost of travel etc)

λ - Calibration Parameter

The model was calibrated for the observed data for two competing modes i.e Minibus and Ambessa City Bus for work, education and other purpose trips.

The calibrated model parameters are provided in Table 2.2 as below:

Table 2.2: Model Calibration parameters

No	Purpose	Calibration Parameter, λ	Goodness of fit R2
1	Work	0.3074	0.82
2	Education	0.3929	0.74
3	Other	0.0627	0.5

Chapter 3

3. MODEL SPECIFICATION

3.1 General Overview

The search for a suitable model specification involves selecting the structure of the model (MNL, HL, Probit, etc) the explanatory variables to consider, and the form in which they enter the utility function (linear, non-linear) and the identification of the individual's choice set (alternatives available) (Juan De Dios Ortuzar, Luis G. Willumsen, 2004).

This means that in the search for model specification, the following four assumptions must be addressed:

- i. The Decision Maker
- ii. The Alternatives
- iii. The Attributes
- iv. The Decision Rule

In broad terms the objectives of specification search include realism, economy, theoretical consistency and policy sensitivity. In other words, we search for a realistic model which does not require too much data and computer resources, does not produce pathological results and is appropriate to the decision context where we want to use it (Juan De Dios Ortuzar, Luis G. Willumsen, 2004)

3.2 The Decision-Maker

In this study, the individual or the decision making unit is a randomly selected working individual living in Bole Sub-City of Addis Ababa. To ensure that the person is a resident of Bole Sub-City, households in the Sub-City were selected randomly and workers in each household were questioned. Moreover, the person must be employed since the model aims to find out what variables influence the work trip mode choice behavior of residents in Bole Sub-City.

3.3 The Alternatives

Choice-set determination is a key problem as we estimate Disaggregate Model by means of the (generally) observed individual choices between alternatives. These should be the alternatives actually considered consciously or unconsciously by the individual. The omission of seemingly unimportant options simply on the grounds of costs, may bias results. In the same vein, the inclusion of alternatives which are actually ignored by certain groups would also bias model estimation (Juan De Dios Ortuzar, Luis G. Willumsen, 2004).

One of the first problems an analyst has to solve, given a typical revealed preferences cross-sectional data set, is that of deciding which alternatives are available to each individual in the sample. It has been noted that this is one of the most difficult of all the issues to resolve, because it reflects the dilemma the modeler has to tackle in arriving at a suitable trade-off between modeling relevance and modeling complexity (Juan De Dios Ortuzar, Luis G. Willumsen, 2004).

In choice set determination, one should follow two steps. The first step is to determine the universal choice Set C for the problem under study. This step may require some judgment about which alternatives can be ignored. The next step is to define the choice set for each individual. This is also generally done by applying reasonable judgments about what constitutes the feasibility of an alternative in any particular situation (Moshe Ben-akiva and Steven R. Lerman, 1985).

A study on the urban transport and road network of Addis Ababa by the Office for the Revision of the Addis Ababa City, disclosed that the different modes of road passenger transport in the city are walking, Anbessa City Bus, Minibus, Taxi, Private cars and service cars. Since Bole Sub-City is one part of the city, these modes can be assumed to be available to residents for their work purpose trips. Therefore, the modes of transport considered in the universal choice set C for the model are:

- Walking
- Small taxis (giving a contract taxi service): - these include only the blue and white painted small taxis with a capacity of five or less seats.

- Minibuses and Small taxis giving regular taxi service: - these are the blue and white painted minibuses and some other minibuses painted other colors but providing the same service in the city. Their seat capacity is between five and twelve.
- Anbessa City Bus: - the only company providing bus transport service in Addis Ababa is the Anbessa Bus Company and its buses are the predominant service givers in the city.
- “Lon Chinas”:- there are privately owned buses in the city providing transport service to the public especially in the peak hour times. Therefore, this alternative includes all privately owned buses providing public transport service.
- Private vehicle as driver and Private vehicle as passenger: - these include all privately owned vehicles.
- Company provided transport: - this includes all company cars, which are not directly given to the individual. A person using this mode of transport should be waiting for the company car at a certain designated place to be picked up and travel to his/her working place.

The rules used for determining which subset of the alternatives is feasible for each individual are entirely judgmental. The following three rules were used to determine the availability of an alternative to an individual

- i. Any worker without a driver’s license cannot drive to work
- ii. Any worker in a household without an automobile cannot drive to work
- iii. Any worker who has not reported company provided transport as available cannot use company provided transport.

3.4 The Attributes

As described in Juan De Dios Ortuzar, Luis G. Willumsen (2004), the choice of mode is affected by the characteristics of the trip maker, the characteristics of the journey and the characteristics of the transport facility. Here we will define the variables considered under each category.

Exogenous Variables

To specify the utility functions for each of the alternatives in this research the following exogenous variables are included in the econometric choice model along with their respective symbols in {} and units in ().

Characteristics of the Trip Maker (Socioeconomic Variables)

Socioeconomic attributes of workers need to be considered in specifying utility functions of travel choice alternatives. For this reason, it is assumed that work travel choices are formed in response to mobility needs, which vary with individual and household socioeconomic characteristics. Therefore the following variables are considered as candidate variables:

- Age {Age}: - the age of the worker
- Sex{Male}:- 1 if male; 0 if female
- License{L}: - 1 if worker possesses driver's license; 0 otherwise
- Car ownership group1{CG1}: - 1 if the household owns a car, 0 if not
- Car ownership group2{CG2}: - 1 if the household owns ≥ 2 cars, 0 if otherwise
- Monthly individual income {MII}:- the monthly income of the individual in Birr
- Household type {HHT}: - 1 if household has child (or children) of age 0-14;0 if otherwise

Characteristics of the Journey

In this research, the journey characteristics like work purpose, start time of travel and journey destination are considered as outlined below:

- *Trip Purpose* :- Only work purpose trips of Bole Sub-City residents are under consideration.
- *Start Time of Travel {PH}*: - this variable checks whether the starting time of travel to work is in the morning peak hour or not by taking the morning peak hour to be from 7:30am to 8:30am in the morning.
- *Central Business District {CBD}*:- 1 if the destination of the journey is located in Addis Ketema Sub-City; 0 if otherwise

Characteristics of the Transport Facility

- *Total Travel Time* (in minutes) {TT}: - The specification for total travel time is different for motorized and non motorized modes based upon the assumption that the utility value of time is not equal for motorized and non-motorized modes of transport. We expect travelers in non-motorized modes to be more sensitive to travel time than travelers in motorized modes (since walking or biking is physically more demanding than traveling in a car).
- *Out-Of-Vehicle Time Divided by Distance* (min/km) {OVTBd}: - this variable is included assuming that the sensitivity of travelers to OVT diminishes with the trip distance. In other words, travelers are more willing to tolerate higher out-of-vehicle time for a long trip rather than for a short trip. Out of vehicle time is determined as the summation of Access, Waiting and Egress Times.
- *Access Time* (in minutes) {AT}: - The time required for an individual to travel from his/her home to a place where public transport is available.
- *Waiting Time* (in minutes) {WT}: - The time spent waiting for the transport mode to be available.
- *Egress Time* (in minutes) {ET}: - The time required for an individual to travel from his/her last public transport to the workplace.
- *Cost by income* (unit less) {CostBii}: - To take account of the expectation that low-income travelers will be more sensitive to travel cost than high-income travelers the cost divided by income is used in place of cost as an explanatory variable. Such a specification implies that the importance of cost in mode choice diminishes with increasing individual income.

3.5 The Decision Rule

The transport mode choice model for the work purpose trips of Bole Sub-City residents is specified as a Multinomial Logit Model (MNL) with linear in parameters utility assuming that the random component of a utility functions are independently and identically distributed, having a double exponential distribution (sometimes called the Weibull or Gumbel distribution). This is the simplest and most popular and practical discrete choice model and the probability can be expressed as

$$P_i = \frac{\exp(\beta X_i)}{\sum_j \exp(\beta X_j)}$$

Where X_i refers to the vector of explanatory variables specific to each alternative and the parameters β are estimated coefficients. These coefficients are assumed to be constant for all individuals but may vary across alternatives.

The following figure shows the Logit model structure for work purpose trips of Bole Sub-City residents.

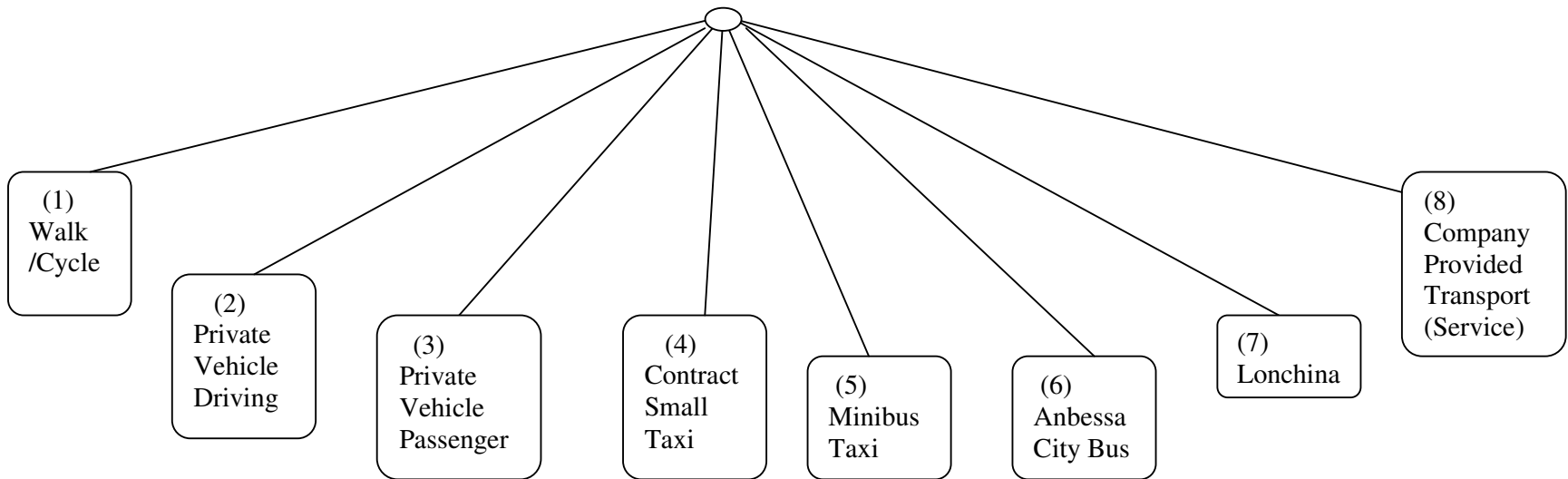


Figure 3.1- Multinomial Logit Model Structure of Transport Mode Choice for Work Purpose Trips of Bole Sub-City Residents

McFadden (1974) showed that a model closely related to the Multinomial Logit Model can be obtained from an underlying utility comparison. Suppose that, for a random draw i from the underlying population (usually, but not necessarily, individuals), the utility from choosing alternative j is

$$Y_{ij}^* = X_{ij}\beta + a_{ij}, j = 0, \dots, J$$

Where a_{ij} ; $j = 0, 1, 2, \dots, J$ are unobservables affecting tastes. Here, X_{ij} is a $1 \times K$ vector that differs across alternatives and possibly across individuals as well.

Let Y_i denote the choice of individual i that maximizes utility:

$$Y_i = \operatorname{argmax}(y_{i0}^*, y_{i2}^*, \dots, y_{iJ}^*)$$

so that Y_i takes on a value in $\{0; 1; \dots; J\}$. As shown by McFadden (1974), if the a_{ij} ,

$j = 0; \dots; J$ are independently distributed with cumulative distribution function $F(a) = \exp[-\exp(-a)]$ - **the type I extreme value distribution** - then

$$P(y_i = j / x_i) = \frac{\exp(x_{ij}\beta)}{\sum_{h=0}^J \exp(x_{ih}\beta)}, j = 0, \dots, J$$

where: P is the probability and h is total number of alternatives.

This response probabilities constitute what is usually called the **Conditional Logit Model** (Jeffrey M. Wooldridge,).

The Conditional Logit Model is intended specifically for problems where consumer or firm choices are at least partly made based on observable attributes of each alternative. The utility level of each choice is assumed to be a linear function in choice attributes, \mathbf{X}_{ij} , with common parameter vector β . This turns out to actually contain the Multinomial Logit Model as a special case by appropriately choosing \mathbf{X}_{ij} . Suppose that W_i is a vector of individual characteristics and

that $P(y_i = j / w_i)$ follows the Multinomial Logit Model with parameters $\delta_j, j = 1, \dots, J$. We can cast this model as the conditional Logit model by defining $x_{ij} = (d1_j w_i, d2_j w_i, \dots, dJ_j w_i)$, where d_{jh} is a dummy variable equal to unity when $j = h$ and $\beta = (\delta_1', \dots, \delta_J')$. Consequently, some authors refer to the conditional Logit model as the Multinomial Logit Model, with the understanding that alternative-specific characteristics are allowed in the response probability.

Empirical applications of the Conditional Logit Model often include individual specific variables by allowing them to have separate effects on the latent utilities. A general model is

$$y_{ij}^* = z_{ij} \gamma + w_i \delta_j + a_{ij}, j = 0, 1, \dots, J$$

With $\delta_0 = 0$ as a normalization, where z_{ij} varies across j and possibly i . if $\delta_j = \delta$ for all j , then $w_i \delta$ drops out of all response probabilities (Jeffrey M. Wooldridge,).

3.6 Limitations of the Multinomial Logit Model

The Conditional Logit Model is very convenient for modeling probabilistic choice, but it has some limitations. An important restriction is the **independence from irrelevant alternatives (IIA) assumption** because it implies that adding another alternative or changing the characteristics of a third alternative does not affect the relative odds between alternatives. This implication is implausible for applications with similar alternatives (Jeffrey M. Wooldridge,).

For our case, there exists clear similarity among some modes than the others in the choice set. For example there is more similarity between private buses(Lonchinas) and Anbessa City Bus since they are widely used mass transportation facilities, available almost every were in the city and charge standard fees for specified distances.

Hausman and McFadden (1984) offer tests of the IIA assumption based on the observation that, if the Conditional Logit Model is true, β can be consistently estimated by conditional Logit by focusing on any subset of alternatives. They apply the Hausman principle, which compares the estimate of β using all alternatives to the estimate using a subset of alternatives (Jeffrey M. Wooldridge,).

3.7 Estimation of the Multinomial Logit

We assume that the sample is exogenously drawn, that is, either random or stratified random with the strata defined on factors that are exogenous to the choice being analyzed and the explanatory variables are exogenous to the choice situation. In short, the variables entering representative utility are independent of the unobserved component of utility.

If an exogenous sample of N decision makers is obtained for the purpose of estimation, since the Logit probabilities take a closed form, the traditional maximum-likelihood procedures can be applied. And, the probability of a person n choosing the alternative that he/she was actually observed to choose can be expressed as

$$\prod_i (P_{ni})^{y_{ni}}$$

Where $y_{ni} = 1$ if person n chose i and zero otherwise

Assuming that each decision maker's choice is independent of that of the other decision maker, the probability of each person in the sample choosing the alternative that he was observed actually to choose is

$$L(\beta) = \prod_{n=1}^N \prod_i (P_{ni})^{y_{ni}}$$

Where β is a vector containing the parameters of the model

The log likelihood function is then

$$LL(\beta) = \sum_{n=1}^N \sum_i y_{ni} \ln P_{ni}$$

and the estimator is the value of β that maximizes this function. McFadden (1974) shows that $LL(\beta)$ is globally concave for linear-in parameters utility and many statistical packages are available for estimation of these models.

At the maximum of the likelihood function, its derivative with respect to each of the parameters is zero:

$$\frac{dLL(\beta)}{d(\beta)} = 0$$

The maximum-likelihood estimates are therefore the values of β that satisfy this first-order condition (Kenneth Train, 2003).

Chapter 4

4. SURVEY DESIGN AND DATA COLLECTON

4.1 Survey Objectives

Revealed preference survey was undertaken for this research. Among the various methods of revealed preference surveys, Household or Home Interview Survey was used as a data source to meet the following objectives:

- Establish the socio-economic characteristics of the people of Bole Sub-City
- Obtain the work trip travel characteristics of the Bole Sub-City residents.
- Establish connection between socio-economic characteristics of a trip maker and his work trip characteristics. This would be carried out on a disaggregated basis of gender, age and income etc. correlating with mode, trip length and other related variables.

4.2 The Population to be Surveyed

Working population of Bole Sub-City is considered as the focus of the survey, which in turn limits the survey population to employed residents of the Sub-City. The estimated total employed population of the Sub-City for the year (2006/07G.C)/1999E.C is 100,664 among which 59,628 are males and the remaing 40,986 are expected to be females. Table 4.1 shows the distribution of employed population of Bole Sub-Cirty aged 10 years and above by Kebele and gender for the year (2006/07G.c)/1999E.C

Table 4.1: Distribution of Employed Population Aged 10 Years and above by Kebele and Gender in Bole Sub-City For the Year (2006/07G.C)/1999E.C

No	Name Of The Kebele In Bole Sub-City	Estimated Total Employed Population		
		Total	Male	Female
1	Kebele 01	9,197	5,451	3,746
2	Kebele 02	8,409	4,984	3,425
3	Kebele 03/05	11,918	6,957	4,961
4	Kebele 04/06/07	12,160	7,196	4,964
5	Kebele 08/09	12,857	7,640	5,217
6	Kebele 10	8,788	5,090	3,698
7	Kebele 11	8,349	4,835	3,514
8	Kebele 12/13	12,975	7,595	5,380
9	Kebele 14/15	11,360	6,980	4,380
10	Kebele 16/18/21/22	2,223	1,404	819
11	Kebele 17/19/20	2,378	1,496	882
Total		100,614	59,628	40,986

Source: - Analytical Report of the 1994 Population and Housing Census of Addis Ababa (C.S.A)

- Addis Ababa City Administration, Policy Study and Planning Commotion

4.3 Data Requirements

The data required is the socio economic characteristics of travelers interviewed and the characteristics of available mode of transport for work purpose trip. In other words, the traveler's choice of mode, travel times, fares, waiting/transfer times, walking distances etc and traveler's socioeconomic data (gender, age, car ownership status, income, etc) related to the mode choice is collected.

The choice of mode is required only for the work purpose trips, i.e. trips from an origin (home or other place) to work. Trips made while they are working, i.e. for the accomplishment of any kind of task in their working period during the day, are not required. As for the pre-work trips the survey will address its presence and since the purpose of pre-work trips affect the mode choice it is included in the survey. However, the trips made from work to different places like back to

home, visit friend, shopping etc are not included since most of these trips are not directly related to the stress of reaching on time for work.

4.4 Required Precision

There is no single sample design for discrete choice analysis that is unambiguously optimal for all values of the parameters. Rather, whether a sample design is good or bad (in the classical sense) depends on the unknown parameter values (Ben-AKiva and Leman, 1985). Moreover, the size of the sample needed to develop a Logit mode choice model usually is in the range 1000-3000 individuals, not counting non-respondents and unusable response. Although the upper end of this range is preferable to the lower, a mode choice model usually can be developed satisfactorily from a sample of 1000 observations if cost or other considerations prohibit acquisition of larger data set (Joel L. Horowitz, Frank S. Koppelman, Steven R. Lerman, 1986). Therefore, considering the economic constraint and time limitation for this research, we have used 1% of the estimated employed population for the year (2006/07G.c)/1999E.c of Bole Sub-City as appropriate sample. In other words we have interviewed 1007 working residents of Bole Sub City.

4.5 Survey Instrument

Questionnaire was used as a major survey instrument in the collection of primary data using household interview. Observation of secondary data was also used to assess the socio economic characteristics and the level of service and availability of transport service for the Sub-City.

4.6 Sampling Unit

The sampling units must be defined to be mutually exclusive and must collectively exhaust the population. In the analysis of urban passenger travel the household has often been used as the sampling unit (Ben-AKiva and Leman, 1985). Therefore, households in Bole Sub-City are taken to be the sampling unit.

4.7 Sampling Frame

Taken collectively, an implicit or explicit list of all the sampling units constitutes the sampling frame. Such lists are often derived from utility records, telephone listings, motor vehicle registry lists, or private directories of firms. Very often the creation of an appropriate sampling frame may be extremely difficult. For example, in many developing countries there are no complete listings of residents or addresses, and it may be necessary actually to visit every residence in an area to establish a reliable sampling frame (Ben-AKiva and Leman, 1985). This is the primary reason for using "deterministic rules" of sampling. In systematic sampling, sample units are drawn by deterministic rather than random rules. For example, rather than drawing a random sample of 5 percent of all households in a region from a published directory, a systematic sampling plan may pick out every 20th household in the directory. As long as there is no inherent bias in setting up the deterministic rule, the systematic sampling plan is essentially equivalent to random sampling, and the choice of one over the other may be a matter of operational convenience (Frank S. Koppelman and Chandra Bhat, 2006)

For this research, Kebeles address lists were taken to be the sampling frame. However, these lists do not include the squatters within each Kebele. To include these households one may visit these residences in the Kebele as recommended in Ben-AKiva and Leman, 1985. But, due to time and budget limitations, they have not been included. To this end, only Kebeles address lists were used as a sampling frame.

4.8 Sampling Strategy

Our sample is very small compared to the estimated total employed population of the Bole Sub-City for the year (2006/07G.c)/1999E.C. Therefore, the employed population of Bole Sub-City is treated as having infinite number of members. This justifies our without replacement sampling strategy; since for an infinite population the distribution of characteristics within the pool of sampling units is unaffected by the removal of any finite number of them (Ben-AKiva and Leman, 1985).

Exogenous sampling is taken as the appropriate strategy of sampling. Bole Sub-City is divided into 11 Kebeles; this is used as a yardstick to classify the residents into 11 geographical strata.

Then 0.25% of the households from each stratum (Kebele) are selected randomly from the respective Kebele's Address list and their location is identified using Nortake. After that, every tenth household is identified and all of available working residents in the household are interviewed until 1% of the estimated employed population in each Kebele is interviewed. Table 4.2, 4.3 and 4.4 show the distribution of employed population aged 10 years and over by sex and Kebele with the respective sample size, distribution of registered households with house ownership and distribution of registered households for each Kebele with the corresponding size of randomly selected houses respectively.

Table 4.2: Distribution of Employed Population Aged 10 Years and over by Sex And Kebele In Bole Sub-City for the Year (2006/07G.C)/1999E.C and the Sample Size for each Kebele

Name of the Kebele in Bole Sub-City	Estimated Total Employed Population			1% of the Employed Population to be Interviewed		
	Total	Male	Female	Total	Male	Female
Kebele 01	9,203	5,451	3,746	92	55	37
Kebele 02	8,412	4,984	3,425	84	50	34
Kebele 03/05	11,981	6,957	4,961	120	70	50
Kebele 04/06/07	12,171	7,196	4,964	122	72	50
Kebele 08/09	12,853	7,640	5,217	129	76	52
Kebele 10	8,854	5,090	3,698	89	51	37
Kebele 11	8,412	4,835	3,514	84	48	35
Kebele 12/13	13,031	7,595	5,380	130	76	54
Kebele 14/15	11,235	6,980	4,380	112	70	44
Kebele 16/18/21/22	2,178	1,404	819	22	14	8
Kebele 17/19/20	2,334	1,496	882	23	15	9
Total	100,664	59,628	40,986	1,007	596	410

Source: - Analytical Report of the 1994 Population and Housing Census of Addis Ababa (C.S.A)

- Addis Ababa City Administration, Policy Study and Planning Commotion

Table 4.3: Distribution of Registered Households with House Ownership for each Kebele in Bole Sub-City for the Year (2006/07G.C)/1999E.C

Name of The Kebele In Bole Sub-City	Total Registered Households in each Kebele	Registered Kebele Owned Houses	%	Registered Rent Houses	%	Registered Privately Owned Houses	%
Kebele 01	3,154	388	12	145	5	2,621	83
Kebele 02	1,475	162	11	145	10	1,168	79
Kebele 03/05	6,454	499	8	355	5	5,600	87
Kebele 04/06/07	4,105	1,642	40	142	3	2,321	57
Kebele 08/09	2,283	97	4	690	30	1,496	66
Kebele 10	3,376	623	18	472	14	2,281	68
Kebele 11	3,325	0	0	324	10	3,001	90
Kebele 12/13	3,013	246	8	368	12	2,399	80
Kebele 14/15	5,650	1,602	28	15	1	4,033	71
Kebele16/18/21/22	3,813	0	0	0	0	3,813	100
Kebele 17/19/20	2,851	10	1	128	4	2,713	95
Total	39499	5269	13	2784	7	31446	80

Source: - Kebeles of Bole Sub-City.

Table 4.4: Distribution of Registered Households for each Kebele in Bole Sub-City for the Year (2006/07G.C)/1999E.C and Corresponding Size of Randomly Selected Houses

Name of The Kebele in Bole Sub-City	Total Registered Households in Each Kebele	0.25% of Total Registered Households in Each Kebele
Kebele 01	3,154	8
Kebele 02	1,475	4
Kebele03/05	6,454	16
Kebele04/06/07	4,105	10
Kebele 08/09	2,283	6
Kebele 10	3,376	8
Kebele 11	3,325	8
Kebele 12/13	3,013	8
Kebele 14/15	5,650	14
Kebele16/18/21/22	3,813	10
Kebele 17/19/20	2,851	7
Total	39499	99

Source: - Kebeles of Bole Sub-City.

4.9 Pre-Testing the Survey

To test the questionnaires, a pilot survey was undertaken on 30 individuals.

4.10 The Survey Management Process

Enumerators were trained on how they will perform the interview and they were provided with support letters from the University to facilitate the response rate and to make the respondents understand the purpose of the research and encourage them to give accurate information.

The heads of households and other working members of the households were visited at their homes, and interviewed by enumerators using the structured questionnaire for recording socioeconomic and work trip characteristics on an average working day.

4.11 Analysis method

Statistical software, Stata v8, was used to develop the required Multinomial Logit Model.

4.12 Data Source

The data used for the research was primary data, which was generated from the household survey conducted for the purpose of accomplishing this research and secondary data obtained from different authorities of the Addis Ababa City Administration.

A total of 1,007 working residents of Bole Sub-City were interviewed. From these interviews relevant data on the one-way work trip characteristics for each employed member and detailed individual and household socio-economic information were obtained. In addition, the distance traveled by each working resident was measured using NORTAKE map based on the reported route of travel. Level of service data for each mode was determined in the following manner.

4.12.1 Level of Service Data for Anbessa Bus

Operational Aspects

Anbessa-Bus Service Enterprise is owned by the Federal Government and is controlled by the Addis Ababa City Administration. Anbessa operates 92 routes in Addis Ababa with an average route length of approximately 10 kilometers. Most operate within the city boundary but there are several longer ones serving outlying areas: the longest is Route 60 (47 kilometers) to Debre Zeit (LEA international, 2004).

Anbessa has two types of operations in Addis Ababa and these are urban bus services that constitute the major part of the operation and contract services, which is primarily for employers in the city for staff transport. The total number of buses assigned to the two types of operations is 349 and 50 respectively with approximate daily kilometers of 73,440 and 1,200 respectively. There are three major Anbessa City Bus terminals (Addis Ketema, Leghar, Menelik Square) and six minor terminals (Megenagna, Lideta, Sidest Kilo, Arat Kilo, Ayer Tena, Shero Meda). Additionally, a total of 860 stops are used for loading and off-loading passengers in the city. Curbside bus stops are spaced between 300 and 500 meters apart (LEA international, 2004). And, Table 4.5 shows key operational characteristics of the enterprise.

Table 4.5: Anbessa - Key Operational Characteristics

No.	Item	Statistic
1.	Days of operation	Mon – Sun
2.	Times of operation	06:00-20:30
3.	Number of routes	93
4.	Number of kilometers operated per month	2 120 000
5.	Number of bus trips per month	200 000
6.	Average bus trip length	10.4 km
7.	Passengers transported per month	20 million
8.	Passenger kilometers per month	208 million
9.	Average kilometers per bus per day	178 km
10.	Passenger trips per weekday	600 000
11.	Average number of passengers per trip	96
12.	Fleet Composition:	
	DAF buses used to provide commuter services	463
	Mercedes Benz buses used as replacement and for private hire services and contracts	±65
	Fiat buses used to provide a service in Jima town	7
13.	Vehicle capacity	100 passengers
14.	Seated - standing ratio per vehicle	30:70
15.	Fleet availability on any given day	90%

Source: Improving Urban Transport through Private Participation in Addis Ababa, status Quo analysis, LEA international (Ltd), 2004

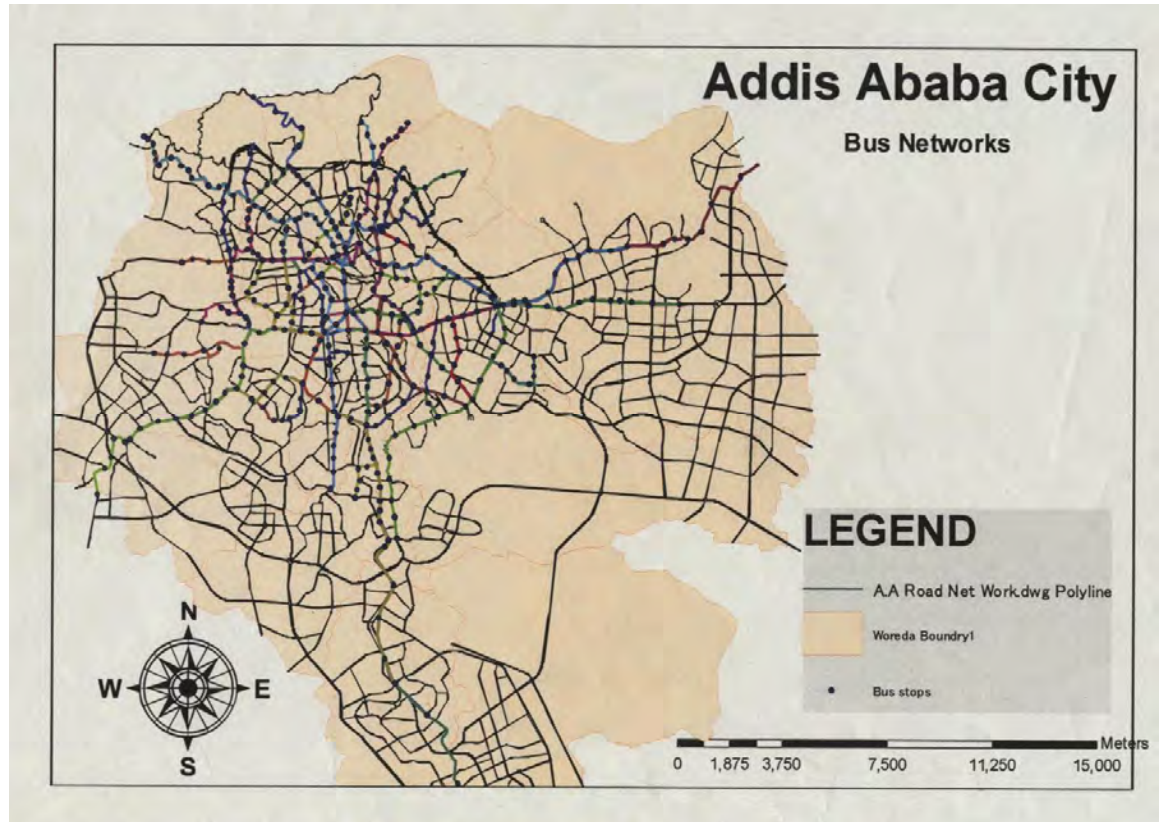


Figure 4.1: Addis Ababa city Anbessa City Bus Network (Anbessa-Bus Service Enterprise)

Financial aspects

The fare structure is flat fare but varies amongst routes based on route length. The minimum fare is ETB0.25 (with some exceptions). Nearly, 40% of passengers pay a fare of ETB 0.25, and 95% of passengers pay a fare of ETB 0.50 or less (LEA international, 2004). For determination of cost in this research, we have developed the following correlation of distance and cost for Anbessa City Bus based on data obtained from Anbessa City Bus Enterprise.

$$Y = 0.0007X^2 + 0.0255X + 0.1237 \quad R^2 = 0.9169$$

Where: X is distance (km) and Y is Anbessa Travel Cost (birr)

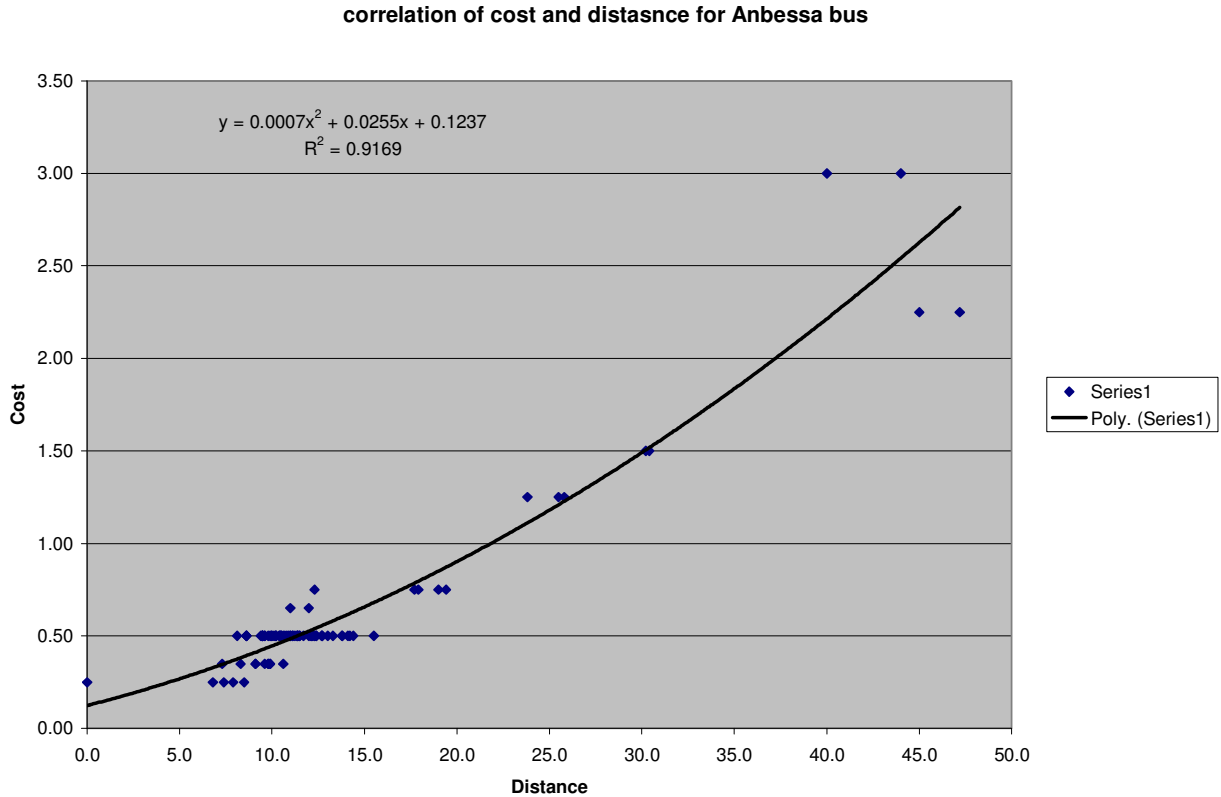


Figure 4.2: Addis Ababa City Anbessa City Bus Cost In Relation To Travel Distance

Travel Time Aspects

Based on data obtained from the Anbessa City Bus Enterprise, it was determined that average speed of Anbessa City Bus is 16km/h, which was used to determine the in-vehicle time of Anbessa City Bus. The average waiting time was also found to be 32 minutes. The average access time for Anbessa City Bus is determined by calculating the average access time for persons who have actually used walking for their travel to work from our survey and it is found to be 12 minutes.

4.12.2 Level of Service Data for Minibus Taxis

Operational Aspects

No formal economic regulation of taxi operations per route or area exists and no restrictions exist in terms of the routes or areas where a taxi may operate. The legal requirements related to taxi operation are: (i) to obtain business license from the Department of Trade and Industry;(ii)

Vehicles to be licensed and inspected annually; (iii) Drivers to be licensed and are in possession of a Class 3 driving license (LEA international, 2004).

According to the urban transport study and preparation of pilot project for Addis Ababa (2005), Minibuses are mainly Toyota Hi-Ace or converted pick-up vehicles (Toyota Hi-Lux and old Peugeot vehicles). The capacity is 11 passengers. There are 105 Minibus taxi routes in Addis Ababa, with the longest close to 25km and an average round trip length of 15km. The Minibuses on an average do, 6 to 8 round trips per day.

Table 4.6: Mini Bus - Key Operational Characteristics

No.	Item	Statistic
1.	Days of operation	Mon – Sun
2.	Times of operation	06:00 – 22:00 Hrs
3.	Number of routes	105
4.	Passengers per day	1,200,000
5.	Fleet size	12,500
6.	Average Route Length	15 Km
7.	Average Trip Length	5.44 Km
8.	No of Trips per Minibus per Day	6 to 8 Round Trips
9.	Fleet Utilization	75 %
10.	Vehicle Utilization	180 Km
11.	Vehicle capacity	11
12.	Operational staff per Minibus trip	Driver & conductor
13.	Ownership	88 % Single Vehicle

Source: Urban Transport Study for Addis Ababa, 2005.

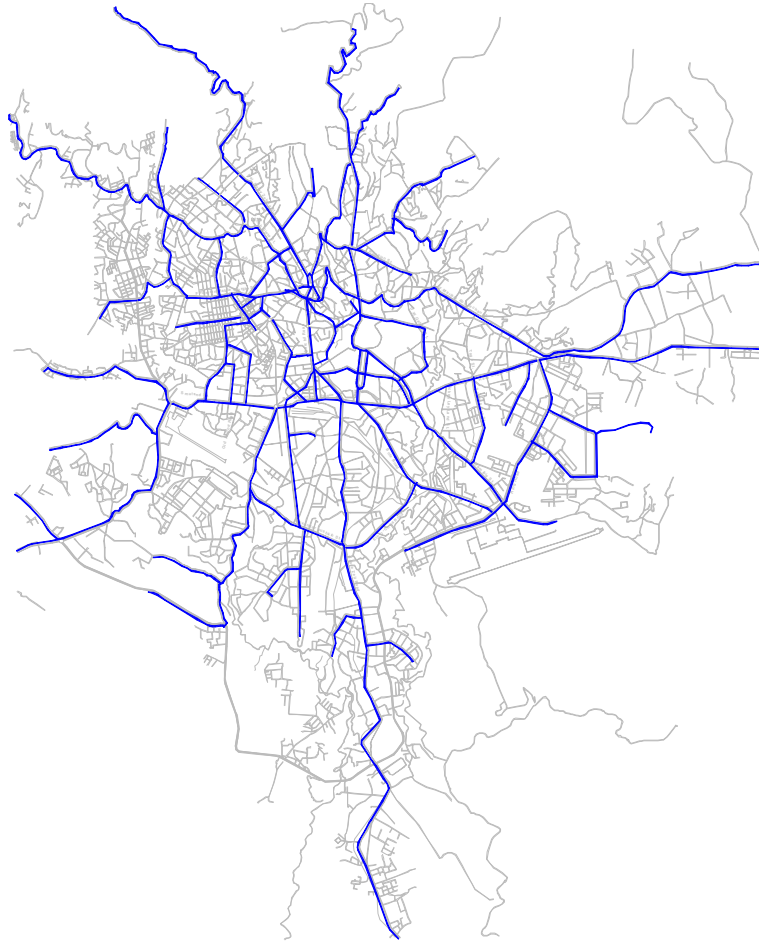


Figure 4.3: The Addis Ababa Minibus taxi routes
(Urban transport study for Addis Ababa, 2005)

Financial Aspects

As per, the Urban Transport Study for Addis Ababa in 2005, the fares of Minibus taxies are regulated by the Government. However, there is malpractice and passengers are charged more, particularly in peak hours. Current tariff for Minibuses are 0.65 Birr for a trip less than 2.5km in length, 1.20 Birr from 2.5 km to 7.0 km, 1.60 Birr from 7.0 km to 10.0 km, 1.75 Birr from 10.0 km to 12.0 km and 2.20 Birr from 12.0 km to 15.0 km (Addis Ababa Transport Branch Office).

Based upon the information obtained from the Addis Ababa Transport Branch Office on Minibus route, we have developed the following correlation of travel distance and cost for Minibus taxi.

$$Y = 0.1202X + 0.5903 \quad R^2 = 0.7787$$

Where: X is distance (km) and Y is Minibus taxi Cost (birr)

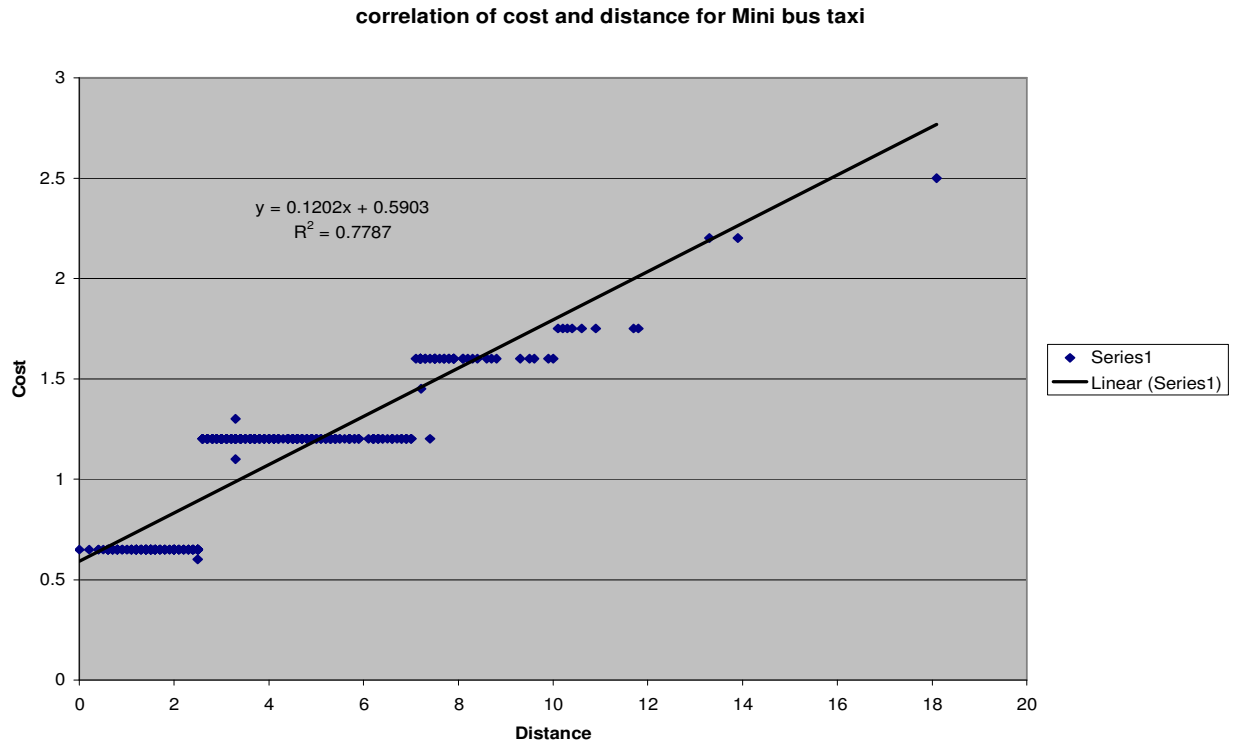


Figure 4.4: Addis Ababa City Minibus Cost In Relation To Travel Distance

Travel Time Aspects

The average access time, average waiting time and average speed for taxi service is determined by calculating the respective averages for the persons who have actually used taxi for their travel to work in our survey. Based on this calculation; the access time, average waiting time and average speed are found to be 9 minutes, 12 minutes and 19Km/h respectively.

4.12.3 Level of Service Data for Small Taxis

The Urban Transport Study for Addis Ababa in 2005 has revealed that Short distance or small taxis provide more personalized services (door-to-door) on contract basis. However, during peak periods they also act as “Minibuses” and transport commuters, but at a higher fare than the Minibuses. Mainly old vehicles, Fiat 124 or Ladas, are used as small taxis. Small taxis are not legally allowed to work at hotels and airports. These services are provided by “yellow taxis”, which have different licenses/ permits (LEA international, 2004).

Financial Aspects

Fares of short-distance taxis are “negotiable” on time and distance basis. A typical fare is in the order of 30 Birr per hour (more is charged if luggage is included) (LEA international, 2004). But this is small for the current market since fuel cost has nearly doubled. Therefore, based on this charge of 30birr per hour, on interviews with different small taxi operators and the vehicle operating cost for small cars which is currently 2.537 birr per km (Kocks Consult GmbH, 2006) the charge was estimated at 3.3 birr per km for contact taxi service, Which is basically an addition of a 30% profit over the vehicle operating costs.

Travel Time Aspects

The average access time, average waiting time and average speed for small taxi contact service is determined by calculating the respective averages for the persons who have actually used contract taxi for their travel to work in our survey. Based on this calculation, the average access time, average waiting time and average speed are found to be 6 minutes, 0 minutes and 22 Km/h respectively.

4.12.4 Level of Service Data for Lonchina

Lonchina (medium size and small Buses) operate on 95 routes in the city. Their tariff is cheaper than taxi but more expensive than Anbessa City Bus.

Financial Aspects

Base on the information obtained from Addis Ababa Transport Branch Office, we have developed the following correlation of travel distance and cost for Lonchina.

$$Y = 0.0944X + 0.1859 \quad R^2 = 0.6884$$

Where: X is distance (km) and Y is Minibus taxi Cost (km)

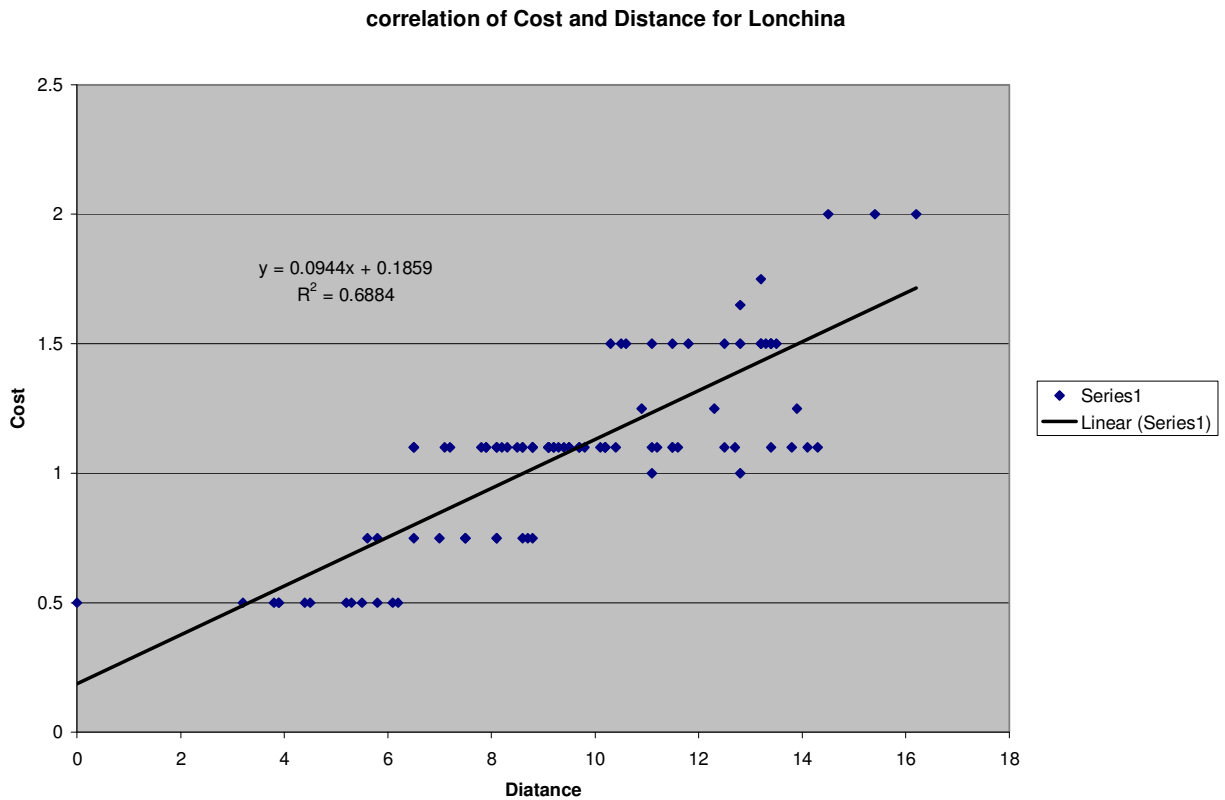


Figure 4.5 Addis Ababa City Lonchina Cost in Relation To Travel Distance

Travel Time Aspects

The average access time, average waiting time and average speed for Lonchina service is determined by calculating the respective averages for the persons who have actually used Lonchina for their travel to work in our survey. Based on this calculation, the average access

time, average waiting time and average speed were found to be 10 minutes, 10 minutes and 20 Km/h respectively.

4.12.5 Level of Service Data for Non-Motorized Transport

Pedestrians and animals form a component of urban mobility for the city of Addis Ababa. The urban mobility study states that over 4.9 million trips are generated daily. Out of this around 4% were made using private cars, 26% using public transport and 70% on foot. Of the 70 percent of the home to work trips that are made on foot, over 50 percent are beyond half hour walking time (Urban Transport Study for Addis Ababa, 2005). In this research, an average travel speed of 2 km/h was taken for walking. This was determined by calculating the average walking speed for the persons who have actually used walking for their travel to work from our survey.

4.12.6 Level of Service Data for Car Drive and Car Passenger Modes of Transport

Financial Aspects

Based on the data found in the feasibility study for Gonder- Debalk Road project undertaken by Kock Consult GmbH June 2006, a vehicle operating cost of 2.537 birr/km for driving car and zero cost for Car Passenger were adopted in the study.

Travel Time Aspects

The average access time, average waiting time and average speed for Car Drive and Car Passenger modes of transport are determined by calculating the respective averages for the persons who have actually used Car Drive and Car Passenger modes of transport during their travels to work in the survey. Based on this calculation, average access time and average waiting time were found to be zero in both cases and average speeds are was found to be 22 Km/h and 48Km/h for Car Drive and Car Passenger modes of transport respectively.

4.12.7 Level of Service Data for Company Provided Mode of Transport

Financial Aspects

There is no cost incurred by the company provided mode transport user for his work trip.

Travel Time Aspects

The average access time, average waiting time and average speed for company provided transport service is determined by calculating the respective averages for the persons who have actually used company provided transport services during their travel to work in the survey. Based on this calculation, the average access time, average waiting time and average speed are found to be 5 minutes, 8 minutes and 24 Km/h respectively.

4.13 Sample Characteristics

Table 4.7 provides information about the availability and usage of each alternative in the sample. Taxi is available to all workers in the Bole Sub-City and is the most frequently chosen alternative. The Anbessa City Bus mode is also available for all trips and account for the next largest share of chosen alternatives. The combined total of taxi and Anbessa City Bus trips represent a bit more than 70% of all work trips. Company provided mode of transport (service), Lonchina, Car passenger, Car Drive and Lada contract constitute 4.6%, 4%, 2.1%, 10.1% and 1.2% respectively. The fraction of trips using non-motorized modes (walk) constitutes 5.6%.

Table 4.7: Sample Statistics of Work Trips Modal Data For Bole Sub-City Residents

NO	Mode	Fraction of Sample with Mode Available (%)	Sample Frequencies of the Chosen Mode	Sample Market Share (%)
1	Walk	100	56	5.6
2	Car Drive	14.1	102	10.1
3	Car Passenger	100	21	2.1
4	Lada Contract	100	12	1.2
5	Taxi	100	608	60.5
6	Anbessa Bus	100	120	11.9
7	Lonchina	100	40	4
8	Service	6.6	46	4.6

Table 4.8: Mean Distance, Total Travel Time, Cost and Monthly Individual Income of Trip Makers With Respect to their Chosen Mode

NO	Chosen Mode	Mean Distance		Mean Monthly Individual Income	
		Km	Ratio	Birr	Ratio
1	Walk	2.4	1	334	1
2	Car Drive	7.3	3.04	3560	10.66
3	Car Passenger	6.8	2.83	1715	5.13
4	Lada Contract	7.8	3.25	3475	10.4
5	Taxi	6.4	2.67	1150	3.44
6	Anbessa Bus	8.3	3.46	611	1.83
7	Lonchina	7.7	3.21	693	2.07
8	Service	7.6	3.17	1293	3.87

Chapter 5

5. RESEARCH RESULTS

5.1 Introduction

In this research we have estimated five different Models for the work trips of Bole Sub City residents as shown table 5.1. These Models are:

- i. The Base Model: - having only the mode related variables (total travel time and cost) in addition to the alternative specific constants.
- ii. Model 1: - having the socioeconomic variable (income) in addition to the alternative specific constants and the mode related variables (total travel time and cost).
- iii. Model 2: - which is an upgrading of Model 1 by adding the trip related variable (peak hour)
- iv. Model 3 and Model 4: - which have different specifications of total travel time and cost including socioeconomic variables i.e gender, age, Car and child ownership and trip related variable CBD to Model 2.

In this chapter we will compare and evaluate these Models by using informal judgment based on tests, goodness of fit measures and statistical tests and as a final task we will choose the optimal Model.

Utility functions for alternative modes of travel under each Model have been expressed. The following Model labels were used in the equations: TT is total travel time, TC is total travel cost, MII is monthly individual income, PH is peak hour dummy variable equal to one if the individual started his trip to work between 7:30am to 8:30am and 0 otherwise, AGE is age in years, CostBii is cost divided by income, OVTBd is out of vehicle time divided by distance, Car is dummy variable equal to one if the household owns car(s) and 0 other wise, 2Car is dummy variable equal to one if the household owns two or more cars and 0 other wise, CHILD is a dummy variable equal to one if the household has child(ren) aged less than fourteen years,

Base Model

$$V_{(walk)} = \beta_{(walk)} + \beta_2 TT_{(walk)}$$

$$V_{(cardrive)} = \beta_{(cardrive)} + \beta_1 TC_{(cardrive)} + \beta_2 TT_{(cardrive)}$$

$$V_{(carpassenger)} = \beta_{(carpassenger)} + \beta_2 TT_{(carpassenger)}$$

$$V_{(Ladacontract)} = \beta_{(Ladacontract)} + \beta_1 TC_{(Ladacontract)} + \beta_2 TT_{(Ladacontract)}$$

$$V_{(Taxi)} = \beta_1 TC_{(Taxi)} + \beta_2 TT_{(Taxi)}$$

$$V_{(Anbessa)} = \beta_{(Anbessa)} + \beta_1 TC_{(Anbessa)} + \beta_2 TT_{(Anbessa)}$$

$$V_{(Lonchina)} = \beta_{(Lonchina)} + \beta_1 TC_{(Lonchina)} + \beta_2 TT_{(Lonchina)}$$

$$V_{(Service)} = \beta_{(Service)} + \beta_2 TT_{(Service)}$$

Model 1

$$V_{(walk)} = \beta_{(walk)} + \beta_2 TT_{(walk)} + \gamma_{(walk)} MII$$

$$V_{(cardrive)} = \beta_{(cardrive)} + \beta_1 TC_{(cardrive)} + \beta_2 TT_{(cardrive)} + \gamma_{(cardrive)} MII$$

$$V_{(carpassenger)} = \beta_{(carpassenger)} + \beta_2 TT_{(carpassenger)} + \gamma_{(carpassenger)} MII$$

$$V_{(Ladacontract)} = \beta_{(Ladacontract)} + \beta_1 TC_{(Ladacontract)} + \beta_2 TT_{(Ladacontract)} + \gamma_{(Ladacontract)} MII$$

$$V_{(Taxi)} = \beta_1 TC_{(Taxi)} + \beta_2 TT_{(Taxi)} + \gamma_{(Taxi)} MII$$

$$V_{(Anbessa)} = \beta_{(Anbessa)} + \beta_1 TC_{(Anbessa)} + \beta_2 TT_{(Anbessa)} + \gamma_{(Anbessa)} MII$$

$$V_{(Lonchina)} = \beta_{(Lonchina)} + \beta_1 TC_{(Lonchina)} + \beta_2 TT_{(Lonchina)} + \gamma_{(Lonchina)} MII$$

$$V_{(Service)} = \beta_{(Service)} + \beta_2 TT_{(Service)} + \gamma_{(Service)} MII$$

Model 2

$$V_{(walk)} = \beta_{(walk)} + \beta_2 TT_{(walk)} + \gamma_{(walk)} MII + \alpha_{(walk)} PH$$

$$V_{(cardrive)} = \beta_{(cardrive)} + \beta_1 TC_{(cardrive)} + \beta_2 TT_{(cardrive)} + \gamma_{(cardrive)} MII$$

$$V_{(carpassenger)} = \beta_{(carpassenger)} + \beta_2 TT_{(carpassenger)} + \gamma_{(carpassenger)} MII$$

$$V_{(Ladacontract)} = \beta_{(Ladacontract)} + \beta_1 TC_{(Ladacontract)} + \beta_2 TT_{(Ladacontract)} + \gamma_{(Ladacontract)} MII$$

$$V_{(Taxi)} = \beta_1 TC_{(Taxi)} + \beta_2 TT_{(Taxi)} + \gamma_{(Taxi)} MII$$

$$V_{(Anbessa)} = \beta_{(Anbessa)} + \beta_1 TC_{(Anbessa)} + \beta_2 TT_{(Anbessa)} + \gamma_{(Anbessa)} MII + \alpha_{(Anbessa)} PH$$

$$V_{(Lonchina)} = \beta_{(Lonchina)} + \beta_1 TC_{(Lonchina)} + \beta_2 TT_{(Lonchina)} + \gamma_{(Lonchina)} MII$$

$$V_{(Service)} = \beta_{(Service)} + \beta_2 TT_{(Service)} + \gamma_{(Service)} MII$$

Model 3

$$V_{(walk)} = \beta_{(walk)} + \beta_4 TT_{(walk)} + \gamma_{1(walk)} MII + \gamma_{2(walk)} MALE + \gamma_{3(walk)} AGE$$

$$V_{(cardrive)} = \beta_{(cardrive)} + \beta_3 CostBii_{(cardrive)} + \beta_5 TT_{(cardrive)} + \beta_6 OVTBd_{(cardrive)} + \gamma_{1(cardrive)} MII + \gamma_{3(cardrive)} AGE + \gamma_{5(cardrive)} 2CAR$$

$$V_{(carpassenger)} = \beta_{(carpassenger)} + \beta_5 TT_{(carpassenger)} + \beta_6 OVTBd_{(carpassenger)} + \gamma_{4(carpassenger)} CAR$$

$$V_{(Ladacontract)} = \beta_{(Ladacontract)} + \beta_3 CostBii_{(Ladacontract)} + \beta_5 TT_{(Ladacontract)} + \beta_6 OVTBd_{(Ladacontract)} + \gamma_{(Ladacontract)} MII$$

$$V_{(Taxi)} = \beta_3 CostBii_{(Taxi)} + \beta_5 TT_{(Taxi)} + \beta_6 OVTBd_{(Taxi)} + \gamma_{(Taxi)} MII$$

$$V_{(Anbessa)} = \beta_{(Anbessa)} + \beta_3 CostBii_{(Anbessa)} + \beta_5 TT_{(Anbessa)} + \beta_6 OVTBd_{(Anbessa)} + \gamma_{1(Anbessa)} MII + \gamma_{2(Anbessa)} MALE + \gamma_{6(Anbessa)} CHILD + \alpha_{1(Anbessa)} PH + \alpha_{2(Anbessa)} CBD$$

$$V_{(Lonchina)} = \beta_{(Lonchina)} + \beta_3 CostBii_{(Lonchina)} + \beta_5 TT_{(Lonchina)} + \beta_6 OVTBd_{(Lonchina)} + \gamma_{(Lonchina)} MII$$

$$V_{(Service)} = \beta_{(Service)} + \beta_5 TT_{(Service)} + \beta_6 OVTBd_{(Service)} + \gamma_{(Service)} MII$$

Model 4

$$V_{(walk)} = \beta_{(walk)} + \beta_2 TT_{(walk)} + \gamma_{1(walk)} MII + \gamma_{2(walk)} MALE + \gamma_{3(walk)} AGE$$

$$V_{(cardrive)} = \beta_{(cardrive)} + \beta_3 CostBii_{(cardrive)} + \beta_2 TT_{(cardrive)} + \beta_6 OVTBd_{(cardrive)} + \gamma_{1(cardrive)} MII + \gamma_{3(cardrive)} AGE + \gamma_{5(cardrive)} 2CAR$$

$$V_{(carpassenger)} = \beta_{(carpassenger)} + \beta_2 TT_{(carpassenger)} + \beta_6 OVTBd_{(carpassenger)} + \gamma_{4(carpassenger)} CAR$$

$$V_{(Ladacontract)} = \beta_{(Ladacontract)} + \beta_3 CostBii_{(Ladacontract)} + \beta_2 TT_{(Ladacontract)} + \beta_6 OVTBd_{(Ladacontract)} + \gamma_{(Ladacontract)} MII$$

$$V_{(Taxi)} = \beta_3 CostBii_{(Taxi)} + \beta_2 TT_{(Taxi)} + \beta_6 OVTBd_{(Taxi)} + \gamma_{(Taxi)} MII$$

$$V_{(Anbessa)} = \beta_{(Anbessa)} + \beta_3 CostBii_{(Anbessa)} + \beta_2 TT_{(Anbessa)} + \beta_6 OVTBd_{(Anbessa)} + \gamma_{1(Anbessa)} MII + \gamma_{2(Anbessa)} MALE + \gamma_{6(Anbessa)} CHILD + \alpha_{1(Anbessa)} PH + \alpha_{2(Anbessa)} CBD$$

$$V_{(Lonchina)} = \beta_{(Lonchina)} + \beta_3 CostBii_{(Lonchina)} + \beta_2 TT_{(Lonchina)} + \beta_6 OVTBd_{(Lonchina)} + \gamma_{(Lonchina)} MII$$

$$V_{(Service)} = \beta_{(Service)} + \beta_2 TT_{(Service)} + \beta_6 OVTBd_{(Service)} + \gamma_{(Service)} MII$$

Table 5.1 Research Results

Table 5.1.1 Research Results for Zero Coefficients, Constants Only and Base Models

Variables	Zero Coefficients Model	Constants Only Model	Base Model	Model 1
Travel Cost (Birr)			-.0092061(-0.59)	-0.0165833(-0.98)
Total Travel Time (Min)			-.0249704(-7.07)	-0.0242011(-6.51)
Monthly Individual Income (Birr)				
Walk				-0.0054253 (-6.85)
Car Drive				0.0005778 (3.88)
Car Passenger				0.0003615 (2.55)
Lada Contract				0.0005789 (4.30)
Taxi(Base)				0.0
Anbessa				-0.0016163 (-6.23)
Lonchina				-0.0011339 (-3.13)
Service				-0.0005888(-2.51)
Alternative Specific Constants				
Walk		-2.384823(-17.08)	-0.5244118 (-2.50)	2.405236 (5.78)
Car Drive		1.449281(7.45)	0.8962151 (2.63)	-0.3950503(-0.88)
Car Passenger		-3.365652(-15.16)	-4.261089 (-16.49)	-4.743031(-13.52)
Lada Contract		-3.925268(-13.47)	-4.234801 (-9.83)	-5.068401(-9.53)
Taxi (Base)		0.0	0.0	0.0
Anbessa		-1.622683(-16.24)	-0.9205077 (-6.48)	0.3450086(1.54)
Lonchina		-2.721295(-16.67)	-2.657552 (-16.23)	-1.681623(-5.53)
Service		1.520255(5.38)	1.096012(3.78)	2.130865(4.06)
Log - Likelihood At Zero		-1832.4929	-1832.4929	-1832.4929
Log - Likelihood At Constants			-963.22434	-963.22434
Log - Likelihood At Convergence	-1832.4929	-963.22434	-914.73224	-809.52729
Rho-Squared Zero W.R.T	NA	0.4744	0.5008	0.5582
Rho-Squared Constants W.R.T	NA	NA	0.05034	0.1596
Number Of Parameters	0	7	9	16

Table 5.1.2 Research Results or Additional Three Models

Variables	Model 2	Model 3	Model 4
Travel Cost (Birr)	-0.0155124(-0.91)		
Cost By Monthly Individual Income		-41.69661(-1.93)	-41.2782(-1.93)
Total Travel Time (Min)	-0.0250796(-6.60)		-0.014314(-3.57)
Total Travel Time Non-Motorized Modes Only (Min)		-0.0140908(-3.28)	
Total Travel Time Motorized Modes Only (Min)		-0.0100045(-0.35)	
OVT By Distance Motorized Modes Only (Min/Km)		-0.0881094(-3.76)	-0.0900883(-4.59)
Monthly Individual Income (Birr)			
Walk	-0.0053327(-6.69)	-0.0060429(-6.54)	-0.0060517(-6.55)
Car Drive	0.0005729(3.90)	0.0005425(2.61)	0.0005458(2.63)
Car Passenger	0.0003603(2.54)	0.0	0.0
Lada Contract	0.0005774(4.32)	0.0004357(2.75)	0.0004371(2.75)
Taxi(Base)	0.0	0.0	0.0
Anbessa	-0.0014608(-5.62)	-0.0014693(-5.47)	-0.0014695(-5.47)
Lonchina	-0.0011378(-3.14)	-0.0010771(-3.02)	-0.001078(-3.02)
Service	-0.0005829(-2.48)	-0.0005732(-2.44)	-0.0005726(-2.44)
Sex Dummy(1= In Male ; 0= Female)			
Walk		1.369157(3.09)	1.369401(3.09)
Anbessa		0.9085835(3.56)	0.9086398(3.56)
Age (Years)			
Walk		0.0662878(3.06)	0.0663425(3.07)
Car Drive		-0.0619296(-2.37)	-0.0619398(-2.37)
Car Ownership Dummy(1= If The Household Owns Car; 0= Otherwise)			
Car Passenger		3.573028(7.33)	3.56354(7.38)
2Cars Ownership Dummy(1= If The Household Owns ≥2car; 0= Otherwise)			
Car Driver		0.9000716(1.79)	0.9013805(1.79)
Child Dummy(1= If The Household Has Child(Ren) With Age Form 0-14 Years ; 0= If They Don't			
Anbessa		0.7073651 (3.28)	0.7079533(3.28)
Peak Hour Dummy (1= Start Of Trip B/N 7:30am To 8:30am;0 =Otherwise)			
Walk	-0.7344271(-1.97)	0.0	0.0
Anbessa	-1.605033(-5.20)	-1.370143(-4.37)	-1.372834(-4.39)
CBD Dummy(1= In CBD ; 0= Not In CBD)			
Anbessa		-0.6962555(-1.35)	-0.6921062(-1.34)
Alternative Specific Constants			
Walk	2.649331(6.00)	-1.885082(-1.46)	-2.03729(- 2.50)
Car Drive	-0.4218159(-0.95)	2.073739(1.47)	1.932846(1.80)
Car Passenger	-4.768124(-13.56)	-5.238223(-4.89)	-5.391247(-14.15)
Lada Contract	-5.105458(-9.63)	-4.685202(-5.31)	-4.787428(-8.33)
Taxi (Base)	0.0	0.0	0.0
Anbessa	0.631877(2.74)	-0.4444644(-0.47)	-0.3090763(-0.97)
Lon China	-1.675012(-5.49)	-1.721955(-5.38)	-1.707166(-5.60)

Variables	Model 2	Model 3	Model 4
Service	2.098929(3.99)	2.074617(2.86)	1.999398 (3.76)
Log - Likelihood At Zero	-1832.4929	-1832.4929	-1832.4929
Log - Likelihood At Constants	-963.22434	-963.22434	-963.22434
Log - Likelihood At Convergence	-790.52946	-727.25811	-727.26979
Rho-Squared W.R.T Zero	0.5686	0.6031	0.6031
Rho-Squared W.R.T Constants	0.1793	0.2450	0.2450
Number Of Parameters	18	26	25
Adjusted Rho-Squared W.R.T Zero	0.558782	0.588944	0.589483
Adjusted Rho-Squared W.R.T Constants	0.166657	0.223625	0.224643

5.2 Informal Tests

A variety of informal tests can be applied to an estimated Model. These tests are designed to assess the reasonableness of the implications of estimated parameters. The most common tests of concern are: the sign of parameters (do the associated variables have a positive or negative effect on the alternatives with which they are associated?), and the difference (positive or negative) within sets of alternative specific variables (does the inclusion of this variable have a more or less positive effect on one alternative relative to another?) (Frank S. Koppelman and Chandra Bhat, 2006).

Signs of Parameters

The most basic test of the estimation results is to examine the signs of the estimated parameters with theory, intuition and judgment regarding the expected impact of the corresponding variables. The estimated coefficients on the travel time and cost variables are expected to be negative, implying that the utility of a mode decreases as the mode becomes slower and/or more expensive. This, in turn, will reduce the choice probability of the corresponding mode (Frank S. Koppelman and Chandra Bhat, 2006). The travel time and cost variables in all four Models have negative sign, which is consistent with the expectation.

Differences in Alternative Specific Variable Parameters Across Alternatives

When analyzing mode choice, we expect a number of variables to be more positive for automobile alternatives, especially Drive Alone, than for other alternatives. These include income, automobile ownership, and home ownership, single-family dwelling unit, etc (Frank S. Koppelman and Chandra, 2006). In our estimation of Model 3, we have found a consistent result

with this argument. That is, car drive mode of transport is found to have a positive parameter for belonging to a household owning more than one car and car passenger mode of transport is associated positively with car ownership.

In the reseach, Taxi was the reference alternative, and we have found positive parameters for car drive and Lada contract modes of transport and negative parameters for walk, Anbessa and Lonchina alternative specific income variables in all estimated Models reflecting that with increasing income, taxi is the most preferred transport mode next to car drive and Lada contract. It was also found that negative income specific parameter for service (company provided transport), which is a free mass transport service to employees. This shows that increasing income will be associated with decreased preference for public transport.

With respect to gender, males were found to have more positive attitude towards walking and usage of Anbessa City Bus than females. Walking is found to have a positive parameter and car drive is found to have a negative sign parameter with respect to age. This may be due to the health concern of the elderly and lesser income of the pensioners.

In Model 3, Anbessa City Bus has positive parameter for the dummy variable indicating the presence of a child aged 0-14 years in the household. This may be attributable to its low cost. Moreover, Anbessa City Bus has negative parameter for peak hour and CBD dummy variables, which can be related to the higher waiting time. Additional informal tests involve comparisons among the estimated income parameters.

The differences in the magnitude of these alternative-specific income parameters indicate the relative impact of increasing income on the utility and, hence, the choice probability of each mode (Frank S. Koppelman and Chandra Bhat, 2006). The results in Table 5-1 show that an increase in income will have a larger negative effect on the utilities of the non-motorized modes (walk) than on those of Anbessa City Bus and Lonchina modes.

5.3 Overall Goodness-of-Fit Measures

The first Model estimation outputs to be examined are the signs and relative values of the coefficients estimates and the significance of individual coefficients. With the estimation of more than one specification it is also useful to compare goodness-of-fit measures. Everything else being equal, a specification with a higher maximum value of likelihood function is considered to be better. It is more convenient to compare the value of likelihood ratio index (rho-squared) that is used in a fashion similar to R^2 in regression analysis. And, there are no general guidelines for when a ρ^2 is sufficiently high (Ben-Akiva and Lerman, 1985).

If the reference Model is the equally likely Model, the rho-square with respect to zero, ρ_0^2 is:

$$\rho_0^2 = 1 - \frac{LL(\hat{\beta})}{LL(0)}$$

Similarly, the rho-square with respect to the constants-only Model is:

$$\rho_0^2 = 1 - \frac{LL(\hat{\beta})}{LL(C)}$$

Where $LL(0)$ represents the log-likelihood with respect to zero coefficients Model, $LL(C)$ represents the log-likelihood for the constants only Model, and $LL(\hat{\beta})$ represents the log-likelihood for the estimated Model (Frank S. Koppelman and Chandra Bhat, 2006).

For the same data set, the ρ^2 of a Model will always increase or at least stay the same when ever new variables are added to the utility functions, a shortcoming it shares with the regression statistic R^2 . For this reason, the adjusted likelihood ratio index (rho-squared bar) is used (Ben-Akiva and Lerman, 1985).

The adjusted rho-squared for the zero Model is given by:

$$\bar{\rho}_0^2 = 1 - \frac{LL(\hat{\beta}) - K}{LL(0)}$$

Where K is the number of degrees of freedom (parameters) used in the Model

The corresponding adjusted rho-squared for the constants only Model is given by:

$$\bar{\rho}_0^2 = 1 - \frac{LL(\hat{\beta}) - K}{LL(C) - K_{ms}}$$

Where K_{ms} is the number of degrees of freedom (parameters) used in the constants only Model (Frank S. Koppelman and Chandra Bhat, 2006)

Research results in Table 5.2 reveals that as we increase the number of explanatory variables from only mode related variables to incorporating the socioeconomic and trip related variables in addition to the mode related variables there is a continuous increase in both goodness of fit statistics rho-squared and adjusted rho-squared. But, Model 4 and Model 3 are found to have the same rho-squared values associated with an increase in the adjusted rho-squared statistics for Model 4. From this observation, we can conclude that Model 4, which includes mode related, socioeconomic and trip related variables, is the best fit for our data.

Table 5.2 Overall Goodness-of-Fit Measures

	Base Model	Model 1	Model 2	Model 3	Model 4
Rho-Squared w.r.t Zero	0.5008	0.5582	0.5686	0.6031	0.6031
Rho-Squared w.r.t Constants	0.05034	0.1596	0.1793	0.2450	0.2450
Adjusted Rho-Squared w.r.t Zero	0.495915	0.549506	0.558782	0.588944	0.589483
Adjusted Rho-Squared w.r.t Constants	0.047919	0.149138	0.166657	0.223625	0.224643

5.4 Statistical Tests

Statistical tests may be used to evaluate formal hypotheses about individual parameters or groups of parameters taken together.

Test of Individual Parameters (the Asymptotic t Test)

There is sampling error associated with the Model parameters because the Models were developed based upon only a sample of the relevant population. The magnitude of the sampling error in a parameter is provided by the standard error associated with that parameter; the larger the standard error, the lower the precision with which the corresponding parameter is estimated. The standard error plays an important role in testing whether a particular parameter is equal to some hypothesized value (Frank S. Koppelman and Chandra Bhat, 2006).

The statistic used for testing the null hypothesis that a parameter $\hat{\beta}_k$ is equal to some hypothesized value, β_k^* is the asymptotic t-statistic, which takes the following form:

$$t - statistic = \frac{\hat{\beta}_k - \beta_k^*}{S_k}$$

Where $\hat{\beta}_k$ is the estimate for the kth parameter

β_k^* is the hypothesized value for the kth parameter and

S_k is the standard error of the estimate.

Sufficiently large absolute values of the *t*-statistic lead to the rejection of the null hypothesis that the parameter is equal to the hypothesized value. When the hypothesized value, β_k^* , is zero, the t-statistic becomes the ratio of the estimated parameter to the standard error. The default estimation output from most software packages includes the t-statistic for the test of the hypothesis that the true value is zero. The rejection of this null hypothesis implies that the corresponding variable has a significant impact on the modal utilities and suggests that the variable should be retained in the Model. Low absolute values of the t-statistic imply that the variable does not contribute significantly to the explanatory power of the Model and can be considered for exclusion (Frank S. Koppelman and Chandra Bhat, 2006).

The selection of a critical value for the t-statistic test is a matter of judgment and depends on the level of confidence with which the analyst wants to test his/her hypotheses. Critical t-values for different levels of confidences for sample sizes those are larger than 150 (which is the norm in mode choice analysis) are shown in Table 5-3. It should be apparent that the critical t-value increases with the desired level of confidence. Thus, one can conclude that a particular variable has no influence on choice (or equivalently that the true parameter associated with the variable is zero) can be rejected at 90% level of confidence if the absolute value of the t-statistic is greater than 1.645 and at 95% level of confidence if the t-statistic is greater than 1.960 (Frank S. Koppelman and Chandra Bhat, 2006).

Table 5-3 Critical t-Values for Selected Confidence Levels and Large Samples

Confidence Level	Critical t-value (Two-tailed test)
90%	1.645
95%	1.960
99%	2.576
99.5%	2.810
99.9%	3.290

In our estimation (Table 5.1), travel cost has not been found significant at 0.1 level in the base Model, Model 1 and Model 2 but when we change the cost specification to cost divided by monthly individual income in Model 3 and Model 4 we able to preserve an absolute t-statistic value of 1.93 which leads us to reject the hypothesis that this variable has no effect on modal utilities at a confidence level higher than 90%.

Total travel time has large absolute t-statistic values; 3.57, 6.6, 6.51, 7.07 for Model 4, Model 2, Model1 and base Model. In Model 3, and Model 4, out of vehicle time by distance specific to motorized modes has also recorded high absolute t-statistic of 3.76 and 4.59 respectively. In all these cases we can reject the null hypothesis that this variable has no effect on modal utilities at a confidence level higher than 99.9%. Thus, this variable should be retained in the Model. However, the splitting of the total travel time into motorized and non-motorized specific variables made the total travel time for the motorized modes insignificant even at 0.1 level of

significance. All of the other t-statistics, except for CBD dummy specific to Anbessa are greater than 1.645 (90% confidence) supporting the inclusion of the corresponding variables.

The lack of significance of the alternative specific constant is immaterial since the constants represent the average effect of all the variables not included in the Model and should always be retained despite the fact that they do not have a well-understood behavioral interpretation (Frank S. Koppelman and Chandra Bhat, 2006).

Tests of Entire Models

The Likelihood Ratio Test

If we wish to test multiple hypotheses simultaneously, we can continue by formulating a test statistic which can be used to compare two Models provided that one is a restricted version of the other; that is, the restricted Model can be obtained by imposing restrictions (setting some parameters to zero, setting pairs of parameters equal to one another and so on) on parameters in the unrestricted Model. This test statistic can then be used for any case when one or more restrictions are imposed on a Model to obtain another Model (Frank S. Koppelman and Chandra Bhat, 2006).

Let LL_u and LL_r denote the values of the log likelihood function at its maximum for the unrestricted and restricted Models, respectively. Again let r denote the number of independent restrictions imposed on the parameters in computing LL_r . The test statistic for the null hypothesis that the restrictions are true is $-2(LL_r - LL_u)$, which is asymptotically distributed as χ^2 (chi squared) with r degrees of freedom. Thus, if $-2(LL_r - LL_u)$ is “large” in the statistical sense, we reject the null hypothesis that the restrictions are true (Ben-Akiva and Lerman, 1985).

Under the null hypothesis that all the coefficients are zero, the statistic $-2(LL(0) - LL(\beta))$ is χ^2 distributed with K (number of parameters of the unrestricted Model) degrees of freedom. This statistic is given as one of the summary measures in the Estimation Results Table of STATA. However, it is not a very useful test because almost always we can reject this null hypothesis at a very low level of significance. It is more informative to test the null hypothesis that all the

coefficients, except for the alternative specific constants, are zero (Frank S. Koppelman and Chandra Bhat, 2006).

Table 5.4 Likelihood Ratio Test for the Null Hypothesis that all the Coefficients are Zero

	Base Model	Model 1	Model 2	Model 3	Model 4
Log - Likelihood at Zero LL (0)	-1832.4929	-1832.4929	-1832.4929	-1832.4929	-1832.4929
Log - Likelihood at Convergence LL ($\hat{\beta}$)	-914.73224	-809.52729	-790.52946	-727.25811	-727.26979
Test Statistics [-2(LL(0)-LL($\hat{\beta}$))]	1835.52132	2045.93122	2083.92688	2210.46958	2210.44622
Number of Restrictions	9	16	18	26	25
Critical Chi-Squared Value at 99.9% Confidence	27.88	39.25	42.31	54.05	52.62
Rejection Confidence	99.9%	99.9%	99.9%	99.9%	99.9%
Rejection Significance	0.001	0.001	0.001	0.001	0.001

Table 5.5 Likelihood Ratio Test for the Null Hypothesis that all the Coefficients, Except for the Alternative Specific Constants, are Zero

	Base Model	Model 1	Model 2	Model 3	Model 4
Log - Likelihood at Constants LL(c)	-963.22434	-963.22434	-963.22434	-963.22434	-963.22434
Log - Likelihood at Convergence LL ($\hat{\beta}$)	-914.73224	-809.52729	-790.52946	-727.25811	-727.26979
Test Statistics [-2(LL(C)-LL ($\hat{\beta}$))]	96.9842	307.3941	345.38976	471.93246	471.9091
Number of Restrictions	2	9	11	19	18
Critical Chi-Squared Value at 99.9% Confidence	13.82	27.88	31.26	43.82	42.31
Rejection Confidence	99.9%	99.9%	99.9%	99.9%	99.9%
Rejection Significance	0.001	0.001	0.001	0.001	0.001

Table 5.4 and 5.5 are application of the log likelihood ratio test where the null hypothesis leads to the zero coefficients Model and the alternative specific constants only Model respectively. In both tests, the null hypothesis is rejected at a very high level of significance (0.001) for all Models. The log-likelihood test can also be applied to test the null hypothesis that the inclusion of certain groups of variables does not add to the explanatory power of the Model. Here, we apply such hypothesis to compare the Base Model with Model-1 and Model-1 with Model-2. In the first case, the null hypothesis is that the inclusion of the alternative specific monthly individual income variable has no effect on the mode choice decision. This null hypothesis is rejected by 99.9% confidence, as shown in table 5.6. The second null hypothesis is Peak hour dummy variables specific to walk and Anbessa have no effect on travel mode choice. This hypothesis is also rejected at significance level of 0.001, as can be observed in the likelihood test in Table 5.7.

Table 5.6 Likelihood Ratio Test The Null Hypothesis That Base Model Is The True Model Compared With Model-1

Variables	Test for Hypothesis
-----------	---------------------

	Base Model is Better Compared to Model-1
Log-Likelihood of Unrestricted Model (<i>LLU</i>)	-809.52729
Log-Likelihood of Restricted Model (<i>LLR</i>)	-914.73224
Test Statistics [-2(<i>LLR-LLU</i>)]	210.4099
Number of Restrictions	7
Critical Chi-Squared Value at 99.9% Confidence	24.32
Rejection Confidence	99.9%
Rejection Significance	0.001

Table 5.7 Likelihood Ratio Test the null hypothesis that Model-1 is the true Model compared with Model-2

Variables	Test for Hypothesis Model-1 is Better Compared to Model-2
Log-Likelihood of Unrestricted Model (<i>LLU</i>)	-790.52946
Log-Likelihood of Restricted Model (<i>LLR</i>)	-809.52729
Test Statistics [-2(<i>LLR-LLU</i>)]	37.99566
Number of Restrictions	2
Critical Chi-Squared Value at 99.9% Confidence	13.82
Rejection Confidence	99.9%
Rejection Significance	0.001

Non-Nested Hypothesis Tests

The likelihood ratio test can only be applied to compare Models, which differ due to the application of restrictions to one of the Models. Such cases are referred to as nested hypothesis tests. However, there are important cases when the rival Models do not have this type of

restricted – unrestricted relationship. For example, we might like to compare the base Model to an alternative specification in which the variable cost divided by income is used to replace cost. This reflects the expectation that the importance of cost diminishes with increasing income. This analysis can be performed by using the non-nested hypothesis test proposed by Horowitz (1982). The non-nested hypothesis test uses the adjusted likelihood ratio index, $\bar{\rho}^2$, to test the hypothesis that the Model with the lower $\bar{\rho}^2$ value is the true Model. In this test, the null hypothesis that the Model with the lower value is the true Model is rejected at the significance level determined by the following equation (Frank S. Koppelman and Chandra Bhat, 2006):

$$\text{Significance Level} = \phi[-(-2(\bar{\rho}_H^2 - \bar{\rho}_L^2) * LL(0) + (K_H - K_L))^{1/2}]$$

Where

$\bar{\rho}_L^2$: is the adjusted likelihood ratio index for the Model with the lower value,

$\bar{\rho}_H^2$: is the adjusted likelihood ratio index for the Model with the higher value,

K_H, K_L : are the numbers of parameters in Models H and L, respectively, and

ϕ : is the standard normal cumulative distribution function.

We have used the non-nested hypothesis test to compare the Model-2 with Model-3 that replaces the cost variable in Model-2 with cost divided by income. Since the Model-3 using cost adjusted for income has the best goodness of fit (highest $\bar{\rho}^2$), the null hypotheses for these tests is that Model-2 having the cost not adjusted by income variable is the true Model.

The result in table 5.8 implies that the null hypotheses that the Models with cost not adjusted by income variable is true is rejected at a significance level greater than 0.001.

Table 5.8 Non-Nested Hypothesis Test for the Null Hypothesis that Model-2 is the True Model Compared With Model-3

Variables	Model 2	Model 3
Log - Likelihood at Zero	-1832.4929	-1832.4929
Number of parameters	18	26
Adjusted Rho-Squared w.r.t Zero	0.558782	0.588944
Significance Level		
$\phi[-(-2(\bar{\rho}_H^2 - \bar{\rho}_L^2) * LL(0) + (K_H - K_L))^{1/2}]$	$\phi[-10.8877593] < 0.001$	

The comparison of Model-3 with Model-4 can be conducted using the Likelihood Ratio Test. The null hypothesis in this case is that Model-4 is the true Model compared with Model-3. And, the result in Table 5.9 indicates that we cannot reject the null hypothesis that Model-4 is better than Model-3 even at 90% confidence interval.

Table 5.9 Likelihood Ratio Test the Null Hypothesis that Model-1 is the True Model Compared With Model-2

Variables	Test for Hypothesis Model-4 is Better Compared to Model-3
Log-Likelihood of Unrestricted Model (LL_U)	-727.25811
Log-Likelihood of Restricted Model (LL_R)	-727.26979
Test Statistics $[-2(LL_R - LL_U)]$	0.02336
Number of Restrictions	1
Critical Chi-Squared Value at 90% Confidence	2.71
Significance	0.01

5.5 Test of The Model Structure

Test of The IIA Assumption

This test involves comparison of Logit Models estimated with subsets of alternatives from the universal choice set. If the IIA Assumption holds for the full choice set, then the Logit Model also applies to a choice from any subset of alternatives.

The linear in parameters Logit Model for the full choice set is

$$P(i / C_n) = \frac{e^{\beta' x_{in}}}{\sum_{j \in C_n} e^{\beta' x_{jn}}}$$

And for a restricted choice set $\tilde{C}_n \subseteq C_n$ we obtain the following Logit Model

$$P(i / \tilde{C}_n) = \frac{e^{\beta' x_{in}}}{\sum_{j \in \tilde{C}_n} e^{\beta' x_{jn}}} \quad i \in \tilde{C}_n \subseteq C_n$$

With the absence of certain alternatives from \tilde{C}_n , it is in general possible to identify only a sub vector of β . This sub vector does not include the alternative specific parameters of alternatives not included in the restricted choice set \tilde{C}_n . The estimation data used for the Model with a restricted set of alternatives not included in the restricted choice set, omitting observations with chosen alternatives not in the restricted choice set.

Thus, if the Logit Model is correctly specified, we can obtain consistent coefficient estimates of the same sub vector of parameters from a Logit Model estimated with the full choice set and from a Logit Model estimated from a restricted choice set. i.e denote the estimated coefficients from the restricted set of alternatives as $\hat{\beta}_c$ and the estimated values or the same sub vector of coefficients from a Model with Model with a full choice set as $\hat{\beta}$. Denote analogously the covariance matrices \sum_{β_c} and \sum_{β} , where the latter matrix is the appropriate sub matrix from

the estimation with a full choice set. Hausman and MaFadden (1984) developed a test for the null hypothesis that $\beta_c = \beta_{\tilde{c}}$. The following test Statistic

$$(\hat{\beta}_{\tilde{c}} - \hat{\beta}_c)' (\sum_{\hat{\beta}_{\tilde{c}}} - \sum_{\hat{\beta}_c})^{-1} (\hat{\beta}_{\tilde{c}} - \hat{\beta}_c)$$

Is asymptotically χ^2 distributed with \tilde{K} degrees of freedom, where \tilde{K} is the number of elements in the sub vector of coefficients that is identifiable from the restricted choice set Model (Moshe Ben-akiva and Steven R. Lerman, 1985).

We have undertaken Hausman specification test for our last two Models using STATA and the test results showed that Model-3 and Model-4 do not violate the IIA assumption at a significance level of 0.01. (See appendix A (STATA Out put))

Therefore based on the above analysis and personal judgment Model-3 is selected as the optimal Model.

Table 5.10: The Optimal Logit Model for Work Trips of Mode Choice for Bole Sub City Residents

Variables	Optimal Model
Cost By Monthly Individual Income	-41.69661(-1.93)*
Total Travel Time Non-Motorized Modes Only (Min)	-0.0140908(-3.28)***
Total Travel Time Motorized Modes Only (Min)	-0.0100045(-0.35)
OVT By Distance Motorized Modes Only (Min/Km)	-0.0881094(-3.76)***
Monthly Individual Income (Birr)	
Walk	-0.0060429(-6.54)***
Car Drive	0.0005425(2.61)***
Car Passenger	0.0
Lada Contract	0.0004357(2.75)***
Taxi(Base)	0.0
Anbessa	-0.0014693(-5.47)***
Lonchina	-0.0010771(-3.02)***
Service	-0.0005732(-2.44)**
Sex Dummy(1= In Male ; 0= Female)	
Walk	1.369157(3.09)***
Anbessa	0.9085835(3.56)***
Age (Years)	
Walk	0.0662878(3.06)***

Variables	Optimal Model
Car Drive	-0.0619296(-2.37)**
Car Ownership Dummy(1= If The Household Owns Car; 0= Otherwise)	
Car Passenger	3.573028(7.33)***
2Cars Ownership Dummy(1= If The Household Owns ≥2car; 0= Otherwise)	
Car Driver	0.9000716(1.79)*
Child Dummy(1= If The Household Has Child(Ren) With Age Form 0-14 Years ; 0= If They Don't	
Anbessa	0.7073651 (3.28)***
Peak Hour Dummy (1= Start Of Trip B/N 7:30am To 8:30am;0 =Otherwise)	
Walk	0.0
Anbessa	-1.370143(-4.37)***
CBD Dummy(1= In CBD ; 0= Not In CBD)	
Anbessa	-0.6962555(-1.35)
Alternative Specific Constants	
Walk	-1.885082(-1.46)
Car Drive	2.073739(1.47)
Car Passenger	-5.238223(-4.89)***
Lada Contract	-4.685202(-5.31)***
Taxi (Base)	0.0
Anbessa	-0.4444644(-0.47)
Lon China	-1.721955(-5.38)***
Service	2.074617(2.86)***
Log - Likelihood At Zero	-1832.4929
Log - Likelihood At Constants	-963.22434
Log - Likelihood At Convergence	-727.25811
Rho-Squared W.R.T Zero	0.6031
Rho-Squared W.R.T Constants	0.2450
Number Of Parameters	26
Adjusted Rho-Squared W.R.T Zero	0.588944
Adjusted Rho-Squared W.R.T Constants	0.223625

*, **, *** means significant at 90%, 95% and 99% confidence respectively

Utility functions in the Optimal Model

$$V_{(walk)} = -1.885082 - 0.0140908TT_{(walk)} - 0.0060429MII + 1.369157MALE + 0.0662878AGE$$

$$V_{(cardrive)} = 2.073739 - 41.69661CostBii - 0.0100045TT - 0.0881094OVTBd - 0.0881094MII - 0.0619296AGE + 0.9000716 2CAR$$

$$V_{(carpassenger)} = -5.238223 - 0.0100045TT - 0.0881094OVTBd + 3.573028 CAR$$

$$V_{(Ladacontract)} = -4.685202 - 41.69661CostBii - 0.0100045TT - 0.0881094OVTBd + 0.0004357MII$$

$$V_{(Taxi)} = -41.6966CostBii - 0.0100045TT - 0.0881094OVTBd$$

$$V_{(Anbessa)} = -0.4444644 - 41.69661CostBii - 0.0100045TT - 0.0881094OVTBd + -0.0014693MII + 0.9085835MALE + 0.7073651 CHILD - 1.370143PH - 0.6962555 CBD$$

$$V_{(Lonchina)} = -1.721955 - 41.69661CostBii - 0.0100045TT - 0.0881094VTBd - 0.0010771MII$$

$$V_{(Service)} = 2.074617 - 0.0100045TT - 0.0881094OVTBd - 0.0005732MII$$

5.6 Demonstration of the Optimal Model

The following table is dedicated to demonstrating the Models ability to explain the mode choices made by the people we have interviewed. This is sort of a self-explanatory procedure since we would try to explain the choices we used to develop the Model. This helps to show that the Model is working properly. The ideal case for the demonstration would be to apply the Model on another data but this is out of reach for our case.

In table 5.11 the probability of choice for the available alternatives to individuals in the survey is calculated and it was found that the calculated probability of the chosen altrnatves using the Optimal Model is the highest in all individual choice cases.

Table 5.11: The Optimal Logit Model Demonstration on the Servey Data

Demonstration of How Well The Model Works			
Model_Chioce_Probability	Trip maker	Mode	Choice
0.0094045	1	Walk	0

0.0012392	1	Car Passenger	0
0.0010833	1	Lada Contract	0
0.0876269	1	Taxi	0
0.0236508	1	Bus	0
0.0075215	1	Lonchina	0
0.8694737	1	Service	1
0	2	Walk	0
0.9998479	2	Car Drive	1
1.36e-12	2	Car Passenger	0
0.000152	2	Lada Contract	0
3.91e-12	2	Taxi	0
0	2	Bus	0
2.66e-36	2	Lonchina	0
0.0100443	3	Walk	0
0.0081213	3	Car Passenger	0
0.0042178	3	Lada Contract	0
0.6984236	3	Taxi	1
0.2141404	3	Bus	0
0.0650527	3	Lonchina	0
0.2001511	4	Walk	0
0.0076411	4	Car Passenger	0
0.0012102	4	Lada Contract	0
0.4965132	4	Taxi	1
0.2254727	4	Bus	0
0.0690116	4	Lonchina	0

5.7 Value of Time

The value of time is equal to the ratio between the derivative of utility with respect to time and the derivative of utility with respect to cost (Frank S. Koppelman and Chandra Bhat, 2006). That is

$$V_{ofT} = \frac{\frac{\partial V_i}{\partial Time_i}}{\frac{\partial V_i}{\partial Cost_i}}$$

The application of this definition to Model 3 where the part of utility function can be expressed as

$$V_i = \dots + \beta_3 \frac{Cost_i}{MII} + \beta_2 TT_i + \dots$$

The value of time becomes

$$V_{ofT} = \frac{\frac{\partial V_i}{\partial Time_i}}{\frac{\partial V_i}{\partial Cost_i}} = \frac{\beta_2}{\beta_3} * MII$$

Using this formula the value of time for different individuals having different monthly individual income can be calculated as Shown in table 5.12

Table 5.12: Value of Time Calculation Using the Optimal Logit Model

Coefficient Of Total Travel Time Motorized Modes Only	Coefficient Of Cost Divided By Monthly Individual Income Coefficient	Case Monthly Individual Income	Individual Income Per Hour	Value Of Time
-0.0100045	-41.69661	300	1.704545455	4.31884031
-0.0100045	-41.69661	500	2.840909091	7.19806718
-0.0100045	-41.69661	700	3.977272727	10.0772941
-0.0100045	-41.69661	900	5.113636364	12.9565209
-0.0100045	-41.69661	1100	6.25	15.8357478
-0.0100045	-41.69661	1300	7.386363636	18.7149747

Chapter 6

6. CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

It has been observed in the previous chapter that the mode choice model has shown continuous improvement in its explanatory power as the model got improved from being restricted to mode related variables to incorporating the socio economic and trip related variables.

Moreover, cost and travel time variables are found to be negatively related to the utility of a mode choice. In addition, it is found that total travel time by non-motorized modes has a more negative effect on the mode choice than total travel time using motorized modes. This shows that traveling on foot is less preferred than traveling using motorized modes.

The effect of increasing monthly individual income on mode choice is found to be positive for the car drive and using contract taxi and negative for traveling on foot, using Anbessa bus, Lonchina and service relative to using taxi. In addition, driving is found to have a more positive parameter than contract taxi indicating that people choose to drive more than to use contract taxi as their incomes grows. Walking on the other hand is associated most negatively with increasing income followed by utilizing Anbessa bus and Lonchina. Comparing the parameters of Anbessa bus and Lonchina indicates that as income grows Lonchina is more preferred to Anbessa bus. The negative sign associated with company provided transport shows that people tend to prefer a more private transport as their income grows even when the service is free.

Regarding the effect of sex on the mode choice, it is found that males have more positive attitude towards walking and using Anbessa bus.

The car ownership variables have shown that the utility of driving will have an additional value of 0.9 units if the person is belonging to a household owning greater than one car and there is an increase of about 3.6 units in the utility of car passenger if the trip maker is belonging to a household owning car.

The utility of Anbessa bus is found to decrease if the person is traveling to the city center, Addis-Ketema Sub-City in which the city's biggest market, Merkato is located, and for peak hour travel. However, an increase in its utility is observed if the person is belonging to a household having a child less than 14 years of age.

6.2 Recommendations

In this research, we have shown that with present knowledge and computer technology, it is possible to model the mode choice for more than two alternatives by considering both the travel maker's and the travel mode's characteristics. Moreover, we have also illustrated that considering both socio-economic and travel mode variables will lead to a better understanding and simulation of the people's behavior in choosing among the competing modes. But from the ten sub-cities of Addis Ababa regional Administration only Bole sub-city is considered in this research. Besides, out of the different purposes of travel, the research only focused on the work purpose trips (Home to work trips). Therefore, we would like to recommend the use of discrete choice models incorporating both the travel maker's and the travel mode's characteristics in future urban transport studies after further research is undertaken to check its effectiveness for other trip purposes and its applicability in other areas. Furthermore, determination of level of service data for different modes of transport on the road networks of Addis Ababa is also another required area for future research.

REFERENCES

1. Charles F. Manski And Daniel L. Mcfadden,1981,Structural Analysis Of Discrete Data And Econometric Applications Editors Cambridge: The Mit Press
2. City Government Of Addis Ababa, Works And Urban Development Bureau, Office For The Revision Of The Addis Ababa Master Plan (ORAAMP),2002, Administrative Restructuring And Service Decentralization In Addis Ababa Executive Summary.
3. Consulting Engineers Services (India) Private Limited 57 In Association With Saba Engineering Plc, 2005, Urban Transport Study And Preparation Of Pilot Project For Addis Ababa, Final Report.
4. F.S. Koppelman, And Chandra Bhart With Technical Support From Vaneet Sethi, Sriram Subramanian, Vincent Bernardin And Jian Zhang, 2006, A Self Instructing Course In Disaggregate Mode Choice Modeling: Multinomial And Nested Logit.
5. Green, William H., 1993, Econometric Analysis 2nd Edition, Prentice-Hall, Inc.
6. J.L Horowitz, F.S. Koppelman, S.R. Lerman, 1986, A Self Instructing Course In Disaggregate Mode Choice Modeling.
7. Jeffrey M. Wooldridge, Econometric Analysis Of Cross Section And Panel Data
8. Juan De Dios Ortuzar, Luis G. Willumsen, 2004, Modeling Transport Third Edition, John Wiley & Sons, Ltd
9. Kenneth Train, Cambridge University Press, 2003, Discrete Choice Methods With Simulation URL: [Http://Elsa.Berkeley.Edu/~Train/Index.Html](http://Elsa.Berkeley.Edu/~Train/Index.Html)
10. Kocks Consult Gmbh ,2006, Feasibility Study for Gonder-Debalk Road Project, ERA
11. Lea International (Ltd), 2004 Improving Urban Transport through Private Participation in Addis Ababa, Status Quo Analysis, Third Draft.
12. M.G.H.Bell, P.W.Bonsall, G.R.Leake, A.D.May, C.A.Nash, C.A.O'flaherty, 1997, Transport Planning And Traffic Engineering, Elsevier Butterworth Heinemann
13. M.J Bruton, 1968, Introduction to transport planning, Hutchinson Technical Education Publishers.
14. Marno Verbeek,2002, A Guide To Modern Econometrics, John Wiley & Sons, Ltd
15. Michel Bierlaire, Intelligent Transportation Systems Program Massachusetts Institute Of Technology May 22, 1997, Discrete Choice Models URL: <http://Web.Mit.Edu/Mbi/Www/Michel.Html>

16. Moshe Ben-Akiva And Steven R. Lerman ,1985, Discrete Choice Analysis: Theory And Application To Travel Demand
17. Policy Study and Plan Commission, Population Unit of Finance and Economy Development Bureau, 2006, Addis Ababa City Administration Population Profile.
18. Theodros Tadesse, Dr. Mesfin Bantyeahu, Lia G. Mariam, 2000, ORAAMP, the Urban Transport and Road Network Of Addis Ababa.
19. Tom Domencich and Daniel L. Mcfadden, 1996, Urban Travel Demand: A Behavioral Analysis, North-Holland Publishing Co.,
[URL:http://emlab.berkeley.edu/users/mcfadden/index.html](http://emlab.berkeley.edu/users/mcfadden/index.html)
20. Torrieri, Vincenzo, 1985, Mobility and Traffic Forecasting, Urban Transportation Sector in AAMP, People's Democratic Republic of Ethiopia, National Urban Planning Institute.
21. Transitional Government Of Ethiopia, Office Of Population And Housing Census Commotion, Central Statistical Authority, The 1994 Population And Housing Census Of Ethiopia, Results For Addis Ababa, Volume-1 Statistical Report.
22. Transitional Government Of Ethiopia, Office Of Population And Housing Census Commotion, Central Statistical Authority, The 1994 Population And Housing Census Of Ethiopia, Results For Addis Ababa, Volume-2 Analytical Report.

Appendix A
STATA Output

IIA Test for model 3

```
. clogit choice walk_asc card_asc carp_asc ladaasc anbassa_asc lonchina_asc
service_asc costBii total_W_travel_t total_V_travel_t total_outVm_travel_t
walk_male anbassa_male walk_age card_age carp_car card__2car walk_income
card_income ladaasc_income anbassa_income lonchina_income service_income
anbassa_14child anbassa_ph anbassa_cbd ,group( trip)
```

```
Iteration 0: log likelihood = -1508.5699
Iteration 1: log likelihood = -869.56653
Iteration 2: log likelihood = -776.65262
Iteration 3: log likelihood = -743.28122
Iteration 4: log likelihood = -730.80115
Iteration 5: log likelihood = -727.57324
Iteration 6: log likelihood = -727.26165
Iteration 7: log likelihood = -727.25811
Iteration 8: log likelihood = -727.25811
```

```
Conditional (fixed-effects) logistic regression      Number of obs      =      6238
LR chi2(26)                                         =      2210.47
Prob > chi2                                         =      0.0000
Pseudo R2                                           =      0.6031
Log likelihood = -727.25811
```

choice	Coef.	Std. Err.	z	P> z	[95% Conf. Interval]
walk_asc	-1.885082	1.287782	-1.46	0.143	-4.409087 .6389241
card_asc	2.073739	1.413813	1.47	0.142	-.697283 4.84476
carp_asc	-5.238223	1.070854	-4.89	0.000	-7.337058 -3.139388
ladaasc	-4.685202	.8817735	-5.31	0.000	-6.413446 -2.956958
anbassa_asc	-.4444644	.9430953	-0.47	0.637	-2.292897 1.403968
lonchina_asc	-1.721955	.3199201	-5.38	0.000	-2.348987 -1.094923
service_asc	2.074617	.7254892	2.86	0.004	.6526838 3.496549
costBii	-41.69661	21.55521	-1.93	0.053	-83.94404 .5508178
total_W_travel_t	-.0140908	.0042955	-3.28	0.001	-.0225099 -.0056717
total_V_travel_t	-.0100045	.0285403	-0.35	0.726	-.0659425 .0459336
t~m_travel_t	-.0881094	.0234323	-3.76	0.000	-.1340358 -.042183
walk_male	1.369157	.4424056	3.09	0.002	.5020582 2.236256
anbassa_male	.9085835	.2555614	3.56	0.000	.4076923 1.409475
walk_age	.0662878	.0216594	3.06	0.002	.0238362 .1087395
card_age	-.0619296	.0261612	-2.37	0.018	-.1132045 -.0106546
carp_car	3.573028	.4874766	7.33	0.000	2.617592 4.528465
card__2car	.9000716	.5033347	1.79	0.074	-.0864462 1.886589
walk_income	-.0060429	.0009239	-6.54	0.000	-.0078538 -.004232
card_income	.0005425	.0002079	2.61	0.009	.0001351 .0009499
ladaasc_income	.0004357	.0001587	2.75	0.006	.0001248 .0007467
anbassa_in~e	-.0014693	.0002685	-5.47	0.000	-.0019956 -.000943
lonchina_i~e	-.0010771	.000357	-3.02	0.003	-.0017768 -.0003775
service_in~e	-.0005732	.0002347	-2.44	0.015	-.0010332 -.0001131
anbassa_14~d	.7073651	.2158803	3.28	0.001	.2842474 1.130483
anbassa_ph	-1.370143	.3135791	-4.37	0.000	-1.984747 -.7555397
anbassa_cbd	-.6962555	.5157104	-1.35	0.177	-1.707029 .3145183

```

-----
. estimates stor modelA

. clogit choice walk_asc card_asc carp_asc ladaC_asc lonchina_asc service_asc
costBii total_W_travel_t total_V_travel_t total_outVm_travel_t walk_male
walk_age card_age carp_car card__2car walk_income card_income ladaC_income
lonchina_income service_income if mode_code !=6 ,group( trip)

```

note: 120 groups (600 obs) dropped due to all positive or all negative outcomes.

```

Iteration 0: log likelihood = -1151.0263
Iteration 1: log likelihood = -557.69161
Iteration 2: log likelihood = -495.46686
Iteration 3: log likelihood = -465.32984
Iteration 4: log likelihood = -452.63927
Iteration 5: log likelihood = -448.90967
Iteration 6: log likelihood = -448.45114
Iteration 7: log likelihood = -448.44282
Iteration 8: log likelihood = -448.44282

```

```

Conditional (fixed-effects) logistic regression    Number of obs    =      4633
                                                    LR chi2(20)      =      2026.88
                                                    Prob > chi2      =      0.0000
Log likelihood = -448.44282                      Pseudo R2       =      0.6932

```

choice	Coef.	Std. Err.	z	P> z	[95% Conf. Interval]
walk_asc	-2.411866	1.370889	-1.76	0.079	-5.098758 .275027
card_asc	1.252366	1.488773	0.84	0.400	-1.665576 4.170308
carp_asc	-6.023841	1.196242	-5.04	0.000	-8.368433 -3.67925
ladaC_asc	-5.122258	.9444763	-5.42	0.000	-6.973397 -3.271118
lonchina_asc	-1.653448	.3242345	-5.10	0.000	-2.288936 -1.01796
service_asc	1.519103	.7542869	2.01	0.044	.0407275 2.997478
costBii	-41.26489	22.01199	-1.87	0.061	-84.4076 1.877815
total_W_tr~t	-.0181276	.0049493	-3.66	0.000	-.027828 -.0084273
total_V_tr~t	-.0356738	.0317116	-1.12	0.261	-.0978274 .0264797
t~m_travel_t	-.078407	.0272654	-2.88	0.004	-.1318463 -.0249678
walk_male	1.362742	.4469665	3.05	0.002	.486704 2.23878
walk_age	.0667847	.0231155	2.89	0.004	.0214791 .1120903
card_age	-.0611891	.0260356	-2.35	0.019	-.1122179 -.0101604
carp_car	3.421085	.4862324	7.04	0.000	2.468087 4.374083
card__2car	.8777603	.5010538	1.75	0.080	-.1042871 1.859808
walk_income	-.0058691	.0009306	-6.31	0.000	-.007693 -.0040452
card_income	.0005724	.0002126	2.69	0.007	.0001557 .0009891
ladaC_income	.0004294	.00016	2.68	0.007	.0001157 .000743
lonchina_i~e	-.0010806	.0003567	-3.03	0.002	-.0017798 -.0003815
service_in~e	-.0005288	.0002326	-2.27	0.023	-.0009847 -.000073

```

. estimates stor modelA1

```

```

. hausman modelA1 modelA

```

```

----- Coefficients -----
| (b) (B) (b-B) sqrt(diag(V_b-V_B))

```

	modelA1	modelA	Difference	S.E.
walk_asc	-2.411866	-1.885082	-.526784	.4700579
card_asc	1.252366	2.073739	-.821373	.4664546
carp_asc	-6.023841	-5.238223	-.7856183	.5331675
ladac_asc	-5.122258	-4.685202	-.4370558	.3383946
lonchina_asc	-1.653448	-1.721955	.0685068	.0527174
service_asc	1.519103	2.074617	-.5555139	.206432
costBii	-41.26489	-41.69661	.431721	4.461022
total_W_tr~t	-.0181276	-.0140908	-.0040368	.0024584
total_V_tr~t	-.0356738	-.0100045	-.0256693	.0138229
t~m_travel_t	-.078407	-.0881094	.0097024	.0139403
walk_male	1.362742	1.369157	-.0064151	.0636891
walk_age	.0667847	.0662878	.0004969	.0080745
card_age	-.0611891	-.0619296	.0007404	.
carp_car	3.421085	3.573028	-.1519429	.
card__2car	.8777603	.9000716	-.0223113	.
walk_income	-.0058691	-.0060429	.0001738	.000111
card_income	.0005724	.0005425	.0000299	.0000446
ladac_income	.0004294	.0004357	-6.36e-06	.0000208
lonchina_i~e	-.0010806	-.0010771	-3.50e-06	.
service_in~e	-.0005288	-.0005732	.0000444	.

b = consistent under Ho and Ha; obtained from clogit
 B = inconsistent under Ha, efficient under Ho; obtained from clogit

Test: Ho: difference in coefficients not systematic

$$\begin{aligned} \text{chi2}(14) &= (b-B)' [(V_b-V_B)^{-1}] (b-B) \\ &= 61.73 \\ \text{Prob}>\text{chi2} &= 0.0000 \end{aligned}$$

IIA Test for model 4

```
. clogit choice walk_asc card_asc carp_asc ladaac_asc anbassa_asc lonchina_asc
service_asc costBii total_travel_t total_outVm_travel_t walk_male
anbassa_male walk_age card_age carp_car card__2car walk_income card_income
ladaac_income anbassa_income lonchina_income service_income anbassa_14child
anbassa_ph anbassa_cbd ,group( trip)
```

```
Iteration 0: log likelihood = -1508.5877
Iteration 1: log likelihood = -870.44215
Iteration 2: log likelihood = -776.57976
Iteration 3: log likelihood = -743.29966
Iteration 4: log likelihood = -730.84728
Iteration 5: log likelihood = -727.59002
Iteration 6: log likelihood = -727.2734
Iteration 7: log likelihood = -727.26979
Iteration 8: log likelihood = -727.26979
```

```
Conditional (fixed-effects) logistic regression    Number of obs    =          6238
                                                    LR chi2(25)      =          2210.45
                                                    Prob > chi2      =           0.0000
Log likelihood = -727.26979                      Pseudo R2        =           0.6031
```

choice	Coef.	Std. Err.	z	P> z	[95% Conf. Interval]
walk_asc	-2.03729	.8150682	-2.50	0.012	-3.634795 - .4397859
card_asc	1.932846	1.071072	1.80	0.071	-.1664158 4.032108
carp_asc	-5.391247	.3809338	-14.15	0.000	-6.137863 -4.64463
ladaac_asc	-4.787428	.5746008	-8.33	0.000	-5.913625 -3.661232
anbassa_asc	-.3090763	.3194662	-0.97	0.333	-.9352184 .3170659
lonchina_asc	-1.707166	.3049336	-5.60	0.000	-2.304825 -1.109507
service_asc	1.999398	.5318707	3.76	0.000	.9569505 3.041845
costBii	-41.2782	21.34223	-1.93	0.053	-83.10821 .5518124
total_travel_t	-.014314	.0040146	-3.57	0.000	-.0221823 -.0064456
total_outVm_travel_t	-.0900883	.0196311	-4.59	0.000	-.1285645 -.0516121
walk_male	1.369401	.4427072	3.09	0.002	.5017111 2.237091
anbassa_male	.9086398	.2555515	3.56	0.000	.4077681 1.409512
walk_age	.0663425	.0216451	3.07	0.002	.0239188 .1087661
card_age	-.0619398	.0261735	-2.37	0.018	-.1132389 -.0106406
carp_car	3.56354	.483112	7.38	0.000	2.616658 4.510422
card__2car	.9013805	.5033405	1.79	0.073	-.0851487 1.88791
walk_income	-.0060517	.0009232	-6.55	0.000	-.0078612 -.0042421
card_income	.0005458	.0002071	2.63	0.008	.0001398 .0009517
ladaac_income	.0004371	.0001587	2.75	0.006	.0001261 .0007481
anbassa_income	-.0014695	.0002684	-5.47	0.000	-.0019957 -.0009434
lonchina_income	-.001078	.000357	-3.02	0.003	-.0017777 -.0003783
service_income	-.0005726	.0002347	-2.44	0.015	-.0010325 -.0001127
anbassa_14child	.7079533	.2158017	3.28	0.001	.2849897 1.130917
anbassa_ph	-1.372834	.3130625	-4.39	0.000	-1.986425 -.7592429
anbassa_cbd	-.6921062	.5149372	-1.34	0.179	-1.701365 .3171522

```
. estimates stor modelA
```

```
. clogit choice walk_asc card_asc carp_asc ladaac_asc anbassa_asc lonchina_asc
service_asc costBii total_travel_t total_outVm_travel_t walk_male
```

```
anbassa_male walk_age card_age carp_car card__2car walk_income card_income
ladac_income anbassa_income lonchina_income service_income anbassa_14child
anbassa_ph anbassa_cbd if mode_code!=6 ,group( trip)
```

```
note: anbassa_asc dropped due to collinearity
note: anbassa_male dropped due to collinearity
note: anbassa_income dropped due to collinearity
note: anbassa_14child dropped due to collinearity
note: anbassa_ph dropped due to collinearity
note: anbassa_cbd dropped due to collinearity
note: 120 groups (600 obs) dropped due to all positive or
      all negative outcomes.
```

```
Iteration 0: log likelihood = -1151.2988
Iteration 1: log likelihood = -558.75608
Iteration 2: log likelihood = -495.71398
Iteration 3: log likelihood = -465.49332
Iteration 4: log likelihood = -452.79895
Iteration 5: log likelihood = -449.07884
Iteration 6: log likelihood = -448.62277
Iteration 7: log likelihood = -448.61454
Iteration 8: log likelihood = -448.61454
```

```
Conditional (fixed-effects) logistic regression      Number of obs      =      4633
                                                    LR chi2(19)        =      2026.53
                                                    Prob > chi2        =      0.0000
Log likelihood = -448.61454                        Pseudo R2          =      0.6931
```

choice	Coef.	Std. Err.	z	P> z	[95% Conf. Interval]
walk_asc	-1.791121	.8803868	-2.03	0.042	-3.516647 - .0655944
card_asc	1.862274	1.075122	1.73	0.083	-.2449266 3.969474
carp_asc	-5.360115	.3848166	-13.93	0.000	-6.114342 -4.605888
ladac_asc	-4.686178	.5856262	-8.00	0.000	-5.833985 -3.538372
lonchina_asc	-1.717569	.3054035	-5.62	0.000	-2.316148 -1.118989
service_asc	1.836343	.5328284	3.45	0.001	.7920191 2.880668
costBii	-43.49292	21.92286	-1.98	0.047	-86.46094 - .5248971
total_trav~t	-.0170618	.0047128	-3.62	0.000	-.0262986 -.007825
t~m_travel_t	-.0715442	.0242518	-2.95	0.003	-.119077 -.0240115
walk_male	1.36665	.4464217	3.06	0.002	.4916794 2.24162
walk_age	.0667912	.0231542	2.88	0.004	.0214099 .1121725
card_age	-.0612281	.0260025	-2.35	0.019	-.1121921 -.0102642
carp_car	3.4588	.483844	7.15	0.000	2.510484 4.407117
card__2car	.8735464	.5008518	1.74	0.081	-.1081052 1.855198
walk_income	-.0058405	.000926	-6.31	0.000	-.0076554 -.0040256
card_income	.0005571	.0002098	2.65	0.008	.0001458 .0009683
ladac_income	.0004237	.0001586	2.67	0.008	.0001129 .0007344
lonchina_i~e	-.0010762	.0003562	-3.02	0.003	-.0017744 -.000378
service_in~e	-.0005305	.0002326	-2.28	0.023	-.0009864 -.0000746

```
. estimates stor modelA1
```

```
. hausman modelA1 modelA
```

```
---- Coefficients ----
```

```
| (b) (B) (b-B) sqrt(diag(V_b-V_B))
```

	modelA1	modelA	Difference	S.E.
walk_asc	-1.791121	-2.03729	.2461694	.3327833
card_asc	1.862274	1.932846	-.0705726	.093233
carp_asc	-5.360115	-5.391247	.0311321	.0545276
ladac_asc	-4.686178	-4.787428	.1012499	.1131017
lonchina_asc	-1.717569	-1.707166	-.0104026	.0169347
service_asc	1.836343	1.999398	-.1630545	.0319316
costBii	-43.49292	-41.2782	-2.214723	5.012087
total_travel_t	-.0170618	-.014314	-.0027478	.0024685
time_travel_t	-.0715442	-.0900883	.0185441	.0142398
walk_male	1.36665	1.369401	-.0027514	.0574693
walk_age	.0667912	.0663425	.0004487	.0082222
card_age	-.0612281	-.0619398	.0007116	.
carp_car	3.4588	3.56354	-.1047395	.0266048
card_2car	.8735464	.9013805	-.0278342	.
walk_income	-.0058405	-.0060517	.0002112	.0000713
card_income	.0005571	.0005458	.0000113	.0000336
ladac_income	.0004237	.0004371	-.0000134	.
lonchina_income	-.0010762	-.001078	1.76e-06	.
service_income	-.0005305	-.0005726	.0000421	.

b = consistent under Ho and Ha; obtained from clogit
 B = inconsistent under Ha, efficient under Ho; obtained from clogit

Test: Ho: difference in coefficients not systematic

$$\begin{aligned} \text{chi2}(14) &= (b-B)' [(V_b-V_B)^{-1}] (b-B) \\ &= 22.38 \\ \text{Prob}>\text{chi2} &= 0.0712 \end{aligned}$$

APPENDIX B

BOLE SUB-CITY

Background of the Sub-City

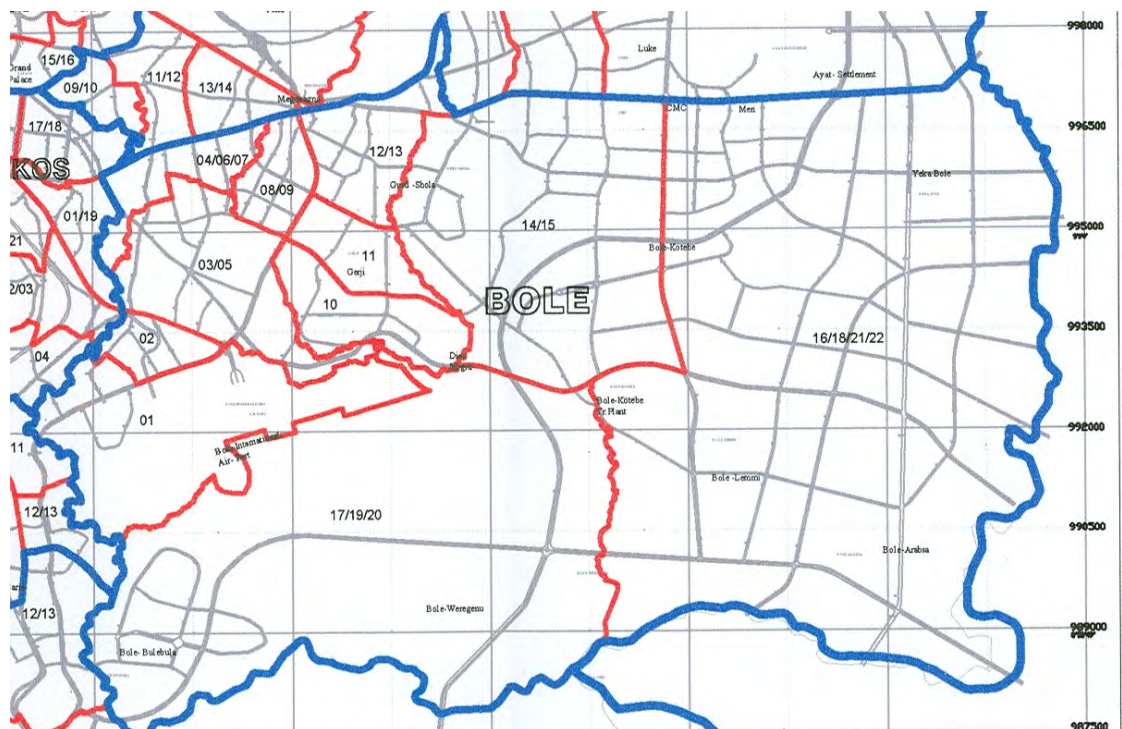
According to the recent (Aug 2004) administration rearrangement, Addis Ababa has been restructured into 10 sub cities each empowered with municipal authority in managing its Sub-City municipal tasks. Bole Sub-City is one of the newly organized sub-cities and is found in the southeastern part of Addis with a total Area 120.93 km² (Bole Sub-City eco-city project). It is relatively well developed and planned. In the previous administration, the present Bole Sub-City was incorporated in Zone 3 that incorporated four Weredas under it (Wereda, 17, 18, 19 and 28). According to the recent administration the previous Wereda 17 is approximately equal in area to Bole Sub-city. It was composed of 12 Kebeles (Kebele 15, 13, 14, 16, 17, 18, 19, 20, 21, 23, 24 and 25). Now, Bole Sub-City is organized into 11 Kebeles, (Kebele 01, 02, 03/05, 04/05/07, 08/09, 10, 11, 12/13, 14/15, 16/18/21/22 and 17/19/20).

The Sub-City has a variety of physical characteristics ranging from semi-urban character, through suburb residential zone to rural land as we move towards the outskirts of the area. This is because of its peripheral location to what is considered as an expansion zone. The Ring Road also splits the Sub-City into two while Addis Ababa International Airport is the major landmark for the Sub-City.

Table A: Description of Kebeles of Bole Sub-City According to the New Organization

No	Newly Established Kebeles	Replaced Kebeles
1	Kebele 01	Wereda 17 Kebele 20B
2	Kebele 02	Wereda 17 Kebele 20A
3	Kebele 03/05	Wereda 17 Kebele 17,18,19,23
4	Kebele 04/06/07	Wereda 17 Kebele 13,14,15,16 Wereda 15 Kebele 35,36
5	Kebele 08/09	Wereda 17 Kebele 24A,24B
6	Kebele 10	Wereda 17 Kebele 25B
7	Kebele 11	Wereda 17 Kebele 25A
8	Kebele 12/13	Wereda 17 Kebele 21A,21B
9	Kebele 14/15	Wereda 28 Kebele 04A,04B
10	Kebele 16/18/21/22	Wereda 28 Kebele 28 Wereda 28 Kebele Yeka Farmers Association Wereda 17 Kebele Bole-Lemi Farmers Association Wereda 17 Kebele Bole-Arbsa Farmers Association
11	Kebele 17/19/20	Wereda 28 Kebele 28 Wereda 17 Kebele Bole-Kotebe Farmers Association Wereda 17 Kebele Bole-Weregenu Farmers Association

Source: Bole Sub-City



Kebele Boundaries of the Bole Sub-city

Demographic Features

In assessing the demographic features of Bole Sub-City, The National Population and Housing Census conducted in year 1994 and latest population prediction data obtained from Addis Ababa Policy Study and Planning Commission have been intensively exploited. Moreover, some relevant data drawn from the household survey, conducted as part of the Urban Transport Study for Addis Ababa (2005) were also utilized.

Population Size

According to the 1994 census, which was carried out nation wide, Wereda 17 recently Bole Sub-city had a total population size of 124,639 (male 53,310, Female 66,329). In Zonal context, Wereda 17 stood 1st in population size. Earlier, during the 1984 National Census the same Wereda, which was then called Kefitegna 17, had a population of 57,448 (Male = 26,977, Female = 30,471).

According to the population unit of the Finance and Economy Development Bureau, the population of Bole Sub-City is estimated to be 325,022 in year 2006/07 G.C (1999E.c). Within the Sub-City the highest population is found in Kebele 12/13 and the lowest in Kebele 16/18/21/22.

Table B: The Bole Sub-City Administration Population by on Age and Sex (2006/07G.c)/1999E.c

Age group	Bole Sub-City Population		
	Total	Male	female
0-4	20598	10063	10535
5-9	33347	16043	17304
10-14	43985	20413	23572
15-19	52490	22514	29976
20-24	43487	19869	23618
25-29	33125	15362	17763
30-34	21969	10710	11259
35-39	21426	9710	11716
40-44	14477	7781	6696
45-49	11651	6446	5205
50-54	8835	4574	4261
55-59	5853	3061	2792
60-64	4956	2378	2578
65-69	3183	1560	1623
70-74	2416	1064	1352
75-79	1366	634	732
≥80	1858	732	1126
total	325022	152914	172108

Source: Addis Ababa City Administration, Policy Study and Planning Commotion

Table C: Bole Sub-City Administration Population Size by Kebele (2006/07G.C)/1999E.C

No	Kebele	Sub-City Population		
		Total	Male	Female
1	01	29,712	13,982	15,730
2	02	27,159	12,781	14,378
3	03/05	38,683	17,844	20,839
4	04/06/07	39,298	18,453	20,845
5	08/09	41,500	19,591	21,909
6	10	28,588	13,051	15,537
7	11	27,159	12,398	14,761
8	12/13	42,074	19,475	22,599
9	14/15	36,277	17,899	18,378
10	16/18/21/22	7,035	3,601	3,434
11	17/19/20	7,537	3,839	3,698
Total		325,022	152,914	172,108

Source: Addis Ababa City Administration, Policy Study and Planning Commotion

Sex Distribution

The sex distribution in Bole Sub-city according to the prediction of the population unit of finance and economy development bureau for the year 2006/07 G.C (1999E.c) is 152,914 male and 172,108 female residents. Based on this prediction the sex ratio of Bole Sub-city is 89 males per 100 females. This means the number of males in Bole Sub-City is less by 11% compared to that of females.

The sex distribution of all Kebeles for the year 1999 E.C (2006/07 G.C) has shown that there are more females than males in all Kebeles except Kebele14/15, 16/18/21/22 and 17/19/20 with respective sex ratio of 97, 95, 96 females per 100 males. The sex ratio of Kebele 01, 02, 04/06/07 and 08/09 is found to be 89 males to 100 females, for Kebele 03/05 and 12/13 it is 86 males to 100 females and for Kebele 10 and 11 it is 84 males to 100 females.

Population Density

According to data obtained from Addis Ababa Policy Study and Planning Commission, the population density of Addis Ababa Administrative city and Bole Sub-city is estimated to be about 6228 and 2688 persons per km² in the year 2006/07 G.C (1999E.c). Out of ten sub cities of Addis Ababa, Addis Ketema and Bole sub cities are the most densely and second sparsely populated parts of the city respectively. Furthermore, the most densely and sparsely populated Kebeles within bole Sub-City are Kebele 08/09 and Kebele 16/18/21/22 respectively.

Table D: Population Density (2006/07G.C)/1999E.C

Community	Population	Total Area (km2)	Population density (person/km2)	Rremark
Bole sub city	325,022	120.93	2688	Second sparsely populated settlement
Addis Ababa	3,363,104	540.01	6228	

Source: Addis Ababa City Administration, Policy Study and Planning Commotion

Table E: Population Density (2006/07G.c)/1999E.c

Community	Total Population	Total Area (Km ²)	Total Area Population Density (Person/Km ²)
Kebele 01	29,712	8.71	3,411
Kebele 02	27,159	1.23	22,080
Kebele 03/05	38,683	5.66	6,834
Kebele 04/06/07	39,298	2.04	19,264
Kebele 08/09	41,500	1.61	25,776
Kebele 10	28,588	2.98	9,593
Kebele 11	27,159	1.89	14,370
Kebele 12/13	42,074	3.2	13,148
Kebele 14/15	36,277	15.82	2,293
Kebele 16/18/21/22	7,035	51.13	138
Kebele 17/19/20	7,537	30.98	243
Total	325,022	125	2,595

Source: Addis Ababa City Administration, Policy Study and Planning Commotion Urban Transport Study and Preparation of Pilot Project for Addis Ababa (2005).

Employed and Unemployed Population

As per the analytical report of the 1994 population and housing census of Addis Ababa, in zone three out of the total active population 69.8% were employed and 30.2% were unemployed. The sex distribution of employment in Zone 3 shows that 72.9% of males and 65.8% of females are employed.

Adopting these rates for the 1999 E.C estimated population; in this economically active population of Bole Sub-City, the total employed and unemployed populations are estimated to be 103,154 and 44,543 respectively. Moreover, from the economically active population 61,290 males and 41,864 females are estimated to be employed, while 22,784 males and 21,759 females are estimated to be unemployed.

Table F: Distribution of Employed and Unemployed Population Aged 10 Years and Over by Sex and Place of Residence for The Year (2006/07g.C)/1999e.C

Region	Pop Aged >10 Years		Active Pop		Employed		Unemployed	
	Male	Female	Male	Female	Male	Female	Male	Female
Bole Sub-City	123,371	141,244	81,795	62,289	59,628	40,986	22,166	21,303
Total	264,620		144,219		100,664		43,555	

Source: - Analytical Report Of The 1994 Population and Housing Census of Addis Ababa (C.S.A)

- Addis Ababa City Administration, Policy Study and Planning Commotion

Table G: Distribution of Employed and Unemployed Population Aged 10 Years and Over by Sex and Place of Residence for the Year (2006/07G.C)/1999E.C

Kebele	Pop Aged >10 Years			Active Pop			Employed			Unemployed		
	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female
01	24,192	11,279	12,909	13,185	7,478	5,693	9,203	5,451	3,746	3,982	2,027	1,947
02	22,113	10,312	11,802	12,052	6,837	5,205	8,412	4,984	3,425	3,640	1,853	1,780
03/05	31,494	14,395	17,098	17,164	9,544	7,540	11,981	6,957	4,961	5,184	2,586	2,579
04/06/07	31,995	14,889	17,107	17,437	9,871	7,544	12,171	7,196	4,964	5,266	2,675	2,580
08/09	33,787	15,808	17,980	18,414	10,481	7,929	12,853	7,640	5,217	5,561	2,840	2,712
10	23,274	10,531	12,743	12,684	6,982	5,620	8,854	5,090	3,698	3,831	1,892	1,922
11	22,113	10,003	12,109	12,052	6,632	5,340	8,412	4,835	3,514	3,640	1,797	1,826
12/13	34,256	15,713	18,540	18,670	10,418	8,176	13,031	7,595	5,380	5,638	2,823	2,796
14/15	29,534	14,441	15,094	16,096	9,574	6,656	11,235	6,980	4,380	4,861	2,595	2,277
16/18/21/22	5,726	2,905	2,822	3,121	1,926	1,245	2,178	1,404	819	942	522	426
17/19/20	6,136	3,095	3,040	3,344	2,052	1,341	2,334	1,496	882	1,010	556	458
Total	264,620	123,371	141,244	144,219	81,795	62,289	100,664	59,628	40,986	43,555	22,166	21,303

Source: - Analytical Report of the 1994 Population and Housing Census of Addis Ababa (C.S.A)

- Addis Ababa City Administration, Policy Study and Planning Commotion

APPENDIX C

ANBESSA BUS ROUTE INFORMATION

ROUTE	ORIGIN- DESTINATION	NO OF BUSES ASIGNED	DAILY TRIP PER BUS	TRAVEL DISTANCE (KM)	TRAVEL TIME (MIN)	WAITING TIME (MIN)	TARIF (BIRR)
1	Kasances- Adisketema	2	22	8.1	37	37	0.50
2	Kore Mekanisa- Addis Ketema	5	17	11.1	48	19	0.50
3	Ayer Tena- Minilik Square	10	19	10.8	44	9	0.50
4	Kaliti-Addis Ketema	6	12	19.4	69	23	0.75
5	Kore Mekanisa- Minilik Square	4	17	12.7	48	24	0.50
6	Kera-Semen Addisu Gebeya	10	20	9.9	41	8	0.35
7	Megenag -- Legtafo	2	17	15.5	50	50	0.50
8	Semen Gebeya- Addis Ketema	3	22	9.4	37	25	0.50
9	Bras Cilinic Bole School-Piassa	4	22	10.5	40	20	0.50
10	Kotebe Teacher Training-Piassa	6	17	12.7	49	16	0.50
11	Mesalemia- Minilik Hospital Kolfe Efoyta	4	20	10.0	40	20	0.50
12	Ferencay Film Center-Addis Ketema	8	20	9.9	41	10	0.35
13	Bella-Addis Ketema	4	20	9.9	41	21	0.50
14	Saris Abo-Piassa	4	18	12.3	48	24	0.50
15	Megenag- Adisketema	2	18	10.4	46	46	0.50
16	Kidane Mihiret- Addis Ketema	6	20	7.9	40	13	0.25
17	Kuskuam-Addis Ketema	6	18	9.1	45	15	0.35
18	Keraniyo-Addis Ketema	6	18	7.3	45	15	0.35
19	Asko-Piassa	6	18	12.2	50	17	0.50
20	Dil Ber-Addis Ketema	3	26	8.6	31	21	0.50

ROUTE	ORIGIN- DESTINATION	NO OF BUSES ASIGNED	DAILY TRIP PER BUS	TRAVEL DISTANCE (KM)	TRAVEL TIME (MIN)	WAITING TIME (MIN)	TARIF (BIRR)
21	Fetno Derash- Addis Ketema Piassa	3	27	8.6	30	20	0.50
22	Samit Leghare	2	19	12.3	43	43	0.50
23	Lamberet-Addis Ketema	4	16	12.4	50	25	0.50
24	Burayu-Degol Square	3	11	17.7	75	50	0.75
25	Legehar-Akaki	6	12	19.0	73	24	0.75
26	Addis Ketema- Sebeta	4	13	25.5	62	31	1.25
27	Legehar-Saris Abo Korki F	8	17	11.4	50	13	0.50
28	Asko Sansuz- Addis Ketema	4	20	11.1	42	21	0.50
29	Addisu Sefer- Addis Ketema	6	16	12.7	55	18	0.50
30	Sululta-Addis Ketema	2	10	25.8	60	60	1.25
31	Legehar-Shiro Meda	8	26	7.4	30	8	0.25
32	Hana Mariam- Legehar	6	19	10.6	43	14	0.35
33	Kotebe Gebriel- Arat Killo	5	19	11.4	44	18	0.50
34	Gofa Camp-Addis Ketema	4	18	9.8	45	23	0.35
35	Cherkos-Addis Ketema Mesalemia Kolfe Efoyta	3	16	9.8	50	33	0.50
36	Kara Kore- Legehar	4	16	11.7	52	26	0.50
37	Keraniyo-Minilik Square	4	16	12.0	52	26	0.50
38	Gofa Camp-Sidist Killo	4	18	11.0	45	23	0.50
39	Bole School- Addis Ketema	4	22	9.6	40	20	0.50
40	Kara Alo-Addis Ketema	3	12	17.9	65	43	0.75
41	Eyesus-Merkato	4	20	8.5	40	20	0.25
42	Megenagna-Bole Legehar	4	24	9.8	35	18	0.35

ROUTE	ORIGIN- DESTINATION	NO OF BUSES ASIGNED	DAILY TRIP PER BUS	TRAVEL DISTANCE (KM)	TRAVEL TIME (MIN)	WAITING TIME (MIN)	TARIF (BIRR)
43	Menagesha- Merkato	2	8	30.2	90	90	1.50
44	Legedadi- Merkato	2	8	30.4	90	90	1.50
45	Legehar-Dil Ber	3	24	8.6	35	23	0.50
46	Gergi-Arat Killo	6	17	11.2	50	17	0.50
47	Yenegew Fire School-Merkato	2	24	8.3	35	35	0.35
48	Bole Michael Square-Minilik Square	3	20	10.9	42	28	0.50
49	Meri Cmc- Megenagna	3	36	6.8	23	15	0.25
50	Total No. 3 Roundabout- Megenagna	3	18	12.1	45	30	0.50
51	Behere Tsige- Lagehar Balcha	3	18	10.1	45	30	0.50
52	Gergi-Merkato	6	15	14.1	59	20	0.50
53	Bole-Shiro Meda	3	21	11.5	40	27	0.50
54	Lafto-Lagehar	4	19	9.5	42	21	0.50
55	Legehar-Ferencyay Kella	2	22	9.5	38	38	0.50
56	Saris Abo-Shiro Meda	3	15	14.2	50	33	0.50
57	Kara-Lagehar	4	15	14.4	55	28	0.50
58	Legehar-World Bank	2	18	12.0	45	45	0.65
59	Belet Hospital- Minilik Square	4	22	11.5	38	19	0.50
60	Debre Zeit- Lagehar	6	9	47.2	90	30	2.25
61	Meri Cmc- Legehar Through Kasanchis	3	18	13.8	48	32	0.50
62	Sebeta-Lagehar	2	12	23.8	63	63	1.25
63	Bole Michael- Wello Sefer	3	23	9.1	35	23	0.35
64	Sidist Killo- Megenagna Gorf Aswgaj	4	26	9.5	40	20	0.50
65	Merkato-World Bank	2	20	11.0	43	43	0.65

ROUTE	ORIGIN- DESTINATION	NO OF BUSES ASIGNED	DAILY TRIP PER BUS	TRAVEL DISTANCE (KM)	TRAVEL TIME (MIN)	WAITING TIME (MIN)	TARIF (BIRR)
66	Addis Ketema- Kara Kore	4	17	10.5	47	24	0.50
67	Mekanisa Square Through Ring Road-Lagehar	4	19	10.2	37	19	0.50
68	Minilik Hospital --Torehailoch Hospital	4	18	10.2	48	24	0.50
70	Kasanchis-Ayer Tena	4	20	11.0	40	20	0.50
71	Bole Gumruke Brass Clinic- Balcha Hospital	3	17	10.6	50	33	0.50
72	Addisu Serer Saris-Legehar	2	31	9.6	40	40	0.35
73	Legehar-Winget School	4	20	10.2	42	21	0.50
74	Gurd Sholla Michael-Merkato Through Ghion Hotel	4	17	13.3	54	27	0.50
75	Sidest Killo-Kera	4	20	10.4	40	20	0.50
76	Megemagma Zerihun Building- Saris Abo	3	16	12.1	50	33	0.50
77	Ayer Tena-Saris Abo	4	18	13.0	48	24	0.50
79	Megenagna- Galcha Hospital	4	18	11.4	48	24	0.50
80	Semen Gebeya- Megenagna	5	18	12.4	48	19	0.50
81	Arat Killo- Yenegew Fire School	2	24	10.7	35	35	0.50
82	Yerer Ber-Balcha Hospital	3	16	11.3	52	35	0.50
83	Cmc-Sidist Killo	3	12	13.8	47	31	0.50
84	Kolfe Efoyta Mesalemia- Lagehar	3	15	9.5	53	35	0.50
85	Addis Ketema- Holeta	2	8	45.0	99	99	2.25
87	Kolfe Square Ring Road-Ayer Tena	2	24	10.5	35	35	0.50

ROUTE	ORIGIN- DESTINATION	NO OF BUSES ASIGNED	DAILY TRIP PER BUS	TRAVEL DISTANCE (KM)	TRAVEL TIME (MIN)	WAITING TIME (MIN)	TARIF (BIRR)
88	Addis Ketema- Chancho	1	2	40.0	100	200	3.00
89	Addis Ketema- Sendafa	1	2	44.0	90	180	3.00
90	Betel Hospital- Legehar	3	20	10.0	40	27	0.50
92	Hana Mariam Bridhe Through Ring Road-Balcha Hospital	3	13	9.6	43	29	0.50
93	Bole Bulbulasaris Abo Through Ring Road- Megenagna	2	10	12.3	37	37	0.75

Source: Anbassa Bus service enterprise

APPENDIX C

ANBESSA BUS ROUTE INFORMATION

ROUTE	ORIGIN- DESTINATION	NO OF BUSES ASIGNED	DAILY TRIP PER BUS	TRAVEL DISTANCE (KM)	TRAVEL TIME (MIN)	WAITING TIME (MIN)	TARIF (BIRR)
1	Kasances- Adisketema	2	22	8.1	37	37	0.50
2	Kore Mekanisa- Addis Ketema	5	17	11.1	48	19	0.50
3	Ayer Tena- Minilik Square	10	19	10.8	44	9	0.50
4	Kaliti-Addis Ketema	6	12	19.4	69	23	0.75
5	Kore Mekanisa- Minilik Square	4	17	12.7	48	24	0.50
6	Kera-Semen Addisu Gebeya	10	20	9.9	41	8	0.35
7	Megenag -- Legtafo	2	17	15.5	50	50	0.50
8	Semen Gebeya- Addis Ketema	3	22	9.4	37	25	0.50
9	Bras Cilinic Bole School-Piassa	4	22	10.5	40	20	0.50
10	Kotebe Teacher Training-Piassa	6	17	12.7	49	16	0.50
11	Mesalemia- Minilik Hospital Kolfe Efoyta	4	20	10.0	40	20	0.50
12	Ferency Film Center-Addis Ketema	8	20	9.9	41	10	0.35
13	Bella-Addis Ketema	4	20	9.9	41	21	0.50
14	Saris Abo-Piassa	4	18	12.3	48	24	0.50
15	Megenag- Adisketema	2	18	10.4	46	46	0.50
16	Kidane Mihiret- Addis Ketema	6	20	7.9	40	13	0.25
17	Kuskuam-Addis Ketema	6	18	9.1	45	15	0.35
18	Keraniyo-Addis Ketema	6	18	7.3	45	15	0.35
19	Asko-Piassa	6	18	12.2	50	17	0.50
20	Dil Ber-Addis	3	26	8.6	31	21	0.50

ROUTE	ORIGIN- DESTINATION	NO OF BUSES ASIGNED	DAILY TRIP PER BUS	TRAVEL DISTANCE (KM)	TRAVEL TIME (MIN)	WAITING TIME (MIN)	TARIF (BIRR)
	Ketema						
21	Fetno Derash- Addis Ketema Piassa	3	27	8.6	30	20	0.50
22	Samit Leghare	2	19	12.3	43	43	0.50
23	Lamberet-Addis Ketema	4	16	12.4	50	25	0.50
24	Burayu-Degol Square	3	11	17.7	75	50	0.75
25	Legehar-Akaki	6	12	19.0	73	24	0.75
26	Addis Ketema- Sebeta	4	13	25.5	62	31	1.25
27	Legehar-Saris Abo Korki F	8	17	11.4	50	13	0.50
28	Asko Sansuz- Addis Ketema	4	20	11.1	42	21	0.50
29	Addisu Sefer- Addis Ketema	6	16	12.7	55	18	0.50
30	Sululta-Addis Ketema	2	10	25.8	60	60	1.25
31	Legehar-Shiro Meda	8	26	7.4	30	8	0.25
32	Hana Mariam- Legehar	6	19	10.6	43	14	0.35
33	Kotebe Gabriel- Arat Killo	5	19	11.4	44	18	0.50
34	Gofa Camp-Addis Ketema	4	18	9.8	45	23	0.35
35	Cherkos-Addis Ketema Mesalemia Kolfe Efoyta	3	16	9.8	50	33	0.50
36	Kara Kore- Legehar	4	16	11.7	52	26	0.50
37	Keraniyo-Minilik Square	4	16	12.0	52	26	0.50
38	Gofa Camp-Sidist Killo	4	18	11.0	45	23	0.50
39	Bole School- Addis Ketema	4	22	9.6	40	20	0.50
40	Kara Alo-Addis Ketema	3	12	17.9	65	43	0.75
41	Eyesus-Merkato	4	20	8.5	40	20	0.25
42	Megenagna-Bole	4	24	9.8	35	18	0.35

ROUTE	ORIGIN- DESTINATION	NO OF BUSES ASIGNED	DAILY TRIP PER BUS	TRAVEL DISTANCE (KM)	TRAVEL TIME (MIN)	WAITING TIME (MIN)	TARIF (BIRR)
	Legehar						
43	Menagesha- Merkato	2	8	30.2	90	90	1.50
44	Legedadi- Merkato	2	8	30.4	90	90	1.50
45	Legehar-Dil Ber	3	24	8.6	35	23	0.50
46	Gergi-Arat Killo	6	17	11.2	50	17	0.50
47	Yenegew Fire School-Merkato	2	24	8.3	35	35	0.35
48	Bole Michael Square-Minilik Square	3	20	10.9	42	28	0.50
49	Meri Cmc- Megenagna	3	36	6.8	23	15	0.25
50	Total No. 3 Roundabout- Megenagna	3	18	12.1	45	30	0.50
51	Behere Tsige- Lagehar Balcha	3	18	10.1	45	30	0.50
52	Gergi-Merkato	6	15	14.1	59	20	0.50
53	Bole-Shiro Meda	3	21	11.5	40	27	0.50
54	Lafto-Lagehar	4	19	9.5	42	21	0.50
55	Legehar-Ferency Kella	2	22	9.5	38	38	0.50
56	Saris Abo-Shiro Meda	3	15	14.2	50	33	0.50
57	Kara-Lagehar	4	15	14.4	55	28	0.50
58	Legehar-World Bank	2	18	12.0	45	45	0.65
59	Belet Hospital- Minilik Square	4	22	11.5	38	19	0.50
60	Debre Zeit- Lagehar	6	9	47.2	90	30	2.25
61	Meri Cmc- Legehar Through Kasanchis	3	18	13.8	48	32	0.50
62	Sebeta-Lagehar	2	12	23.8	63	63	1.25
63	Bole Michael- Wello Sefer	3	23	9.1	35	23	0.35
64	Sidist Killo- Megenagna Gorf Aswgaj	4	26	9.5	40	20	0.50

ROUTE	ORIGIN- DESTINATION	NO OF BUSES ASIGNED	DAILY TRIP PER BUS	TRAVEL DISTANCE (KM)	TRAVEL TIME (MIN)	WAITING TIME (MIN)	TARIF (BIRR)
65	Merkato-World Bank	2	20	11.0	43	43	0.65
66	Addis Ketema- Kara Kore	4	17	10.5	47	24	0.50
67	Mekanisa Square Through Ring Road-Lagehar	4	19	10.2	37	19	0.50
68	Minilik Hospital --Torehailoch Hospital	4	18	10.2	48	24	0.50
70	Kasanchis-Ayer Tena	4	20	11.0	40	20	0.50
71	Bole Gumruke Brass Clinic- Balcha Hospital	3	17	10.6	50	33	0.50
72	Addisu Serer Saris-Legehar	2	31	9.6	40	40	0.35
73	Legehar-Winget School	4	20	10.2	42	21	0.50
74	Gurd Sholla Michael-Merkato Through Ghion Hotel	4	17	13.3	54	27	0.50
75	Sidest Killo-Kera	4	20	10.4	40	20	0.50
76	Megemagma Zerihun Building- Saris Abo	3	16	12.1	50	33	0.50
77	Ayer Tena-Saris Abo	4	18	13.0	48	24	0.50
79	Megenagna- Galcha Hospital	4	18	11.4	48	24	0.50
80	Semen Gebeya- Megenagna	5	18	12.4	48	19	0.50
81	Arat Killo- Yenegew Fire School	2	24	10.7	35	35	0.50
82	Yerer Ber-Balcha Hospital	3	16	11.3	52	35	0.50
83	Cmc-Sidist Killo	3	12	13.8	47	31	0.50
84	Kolfe Efoyta Mesalemia- Lagehar	3	15	9.5	53	35	0.50
85	Addis Ketema- Holeta	2	8	45.0	99	99	2.25
87	Kolfe Square Ring Road-Ayer	2	24	10.5	35	35	0.50

ROUTE	ORIGIN- DESTINATION	NO OF BUSES ASIGNED	DAILY TRIP PER BUS	TRAVEL DISTANCE (KM)	TRAVEL TIME (MIN)	WAITING TIME (MIN)	TARIF (BIRR)
	Tena						
88	Addis Ketema- Chancho	1	2	40.0	100	200	3.00
89	Addis Ketema- Sendafa	1	2	44.0	90	180	3.00
90	Betel Hospital- Legehar	3	20	10.0	40	27	0.50
92	Hana Mariam Bridhe Through Ring Road-Balcha Hospital	3	13	9.6	43	29	0.50
93	Bole Bulbulasaris Abo Through Ring Road- Megenagna	2	10	12.3	37	37	0.75

Source: Anbassa Bus service enterprise

APPENDIX D

MINI BUS ROUTE INFORMATION

Route No	Start of Route	End of Route	Km	Tariff
1	Merkato Autobus Tera	Abinet	1.1	0.65
2	Merkato Autobus Tera	Kefitegna Fird	1.9	0.65
3	Merkato Autobus Tera	Meksiko	3.1	1.2
4	Merkato Autobus Tera	Genet Hotel	4.1	1.2
5	Merkato Autobus Tera	Bulgria	5.2	1.2
6	Merkato Autobus Tera	Kera	6.2	1.2
7	Merkato Autobus Tera	Gofa Mazoria	7.4	1.6
8	Merkato Autobus Tera	Gofa	9.5	1.6
9	Merkato Sebategna	Abinet	1.1	0.65
10	Merkato Sebategna	Kefitegna Fird	1.9	0.65
11	Merkato Sebategna	Meksiko	3.1	1.2
12	Merkato Sebategna	Genet Hotel	4.1	1.2
13	Merkato Sebategna	Bulgria	5.2	1.2
14	Merkato Sebategna	Kera	6.2	1.2
15	Merkato Sebategna	Gotera	7.6	1.6
16	Merkato Sebategna	Sibsite Negasi School	8.6	1.6
17	Merkato Sebategna	Race Enginnering	10.6	1.75
18	Merkato Sebategna	Chimad	11.8	1.75
19	Merkato Sebategna	Menged Transport Study Center	13.3	2.2
20	Merkato Sebategna	Kality	18.1	2.5
21	Merkato Raguel	Habite Giorgis Dildiy	0.6	0.65
22	Merkato Raguel	Degol Adebabay	1.7	0.65
23	Merkato Raguel	Arat Kolo	3.11	1.2
24	Merkato Raguel	Sidist Kilo	4.21	1.2
25	Merkato Raguel	Sositgna Shialeka	4.91	1.2
26	Merkato Raguel	Bela(Torhailoch)	7.21	1.45
27	Merkato Behined Sinimaras	Teklehaimanot	0.6	0.65
28	Merkato Behined Sinimaras	Guma Kuteba	2	0.65
29	Merkato Behined Sinimaras	Meksiko	2.8	1.2
30	Merkato Behined Sinimaras	Showa Dabo	3.5	1.2
31	Merkato Behined Sinimaras	Cherkos	4.5	1.2
32	Merkato Tana	Teklehaimanot	0.8	0.65
33	Merkato Tana	Mortgage Bank	2.9	1.2
34	Merkato Tana	Sport Commition	3.4	1.2
35	Merkato Tana	4th Kifletor	4.6	1.2
36	Merkato Tana	Hawi Hotel	6.3	1.2
37	Merkato Tana	Gotra	7.5	1.6

Route No	Start of Route	End of Route	Km	Tariff
38	Merkato Tana	Tikur Anbessa	1.8	0.65
39	Merkato Tana	Legehar	3.4	1.2
40	Merkato Tana	Filamingo	4.6	1.2
41	Merkato Tana	Bole Matemia Bet	6.2	1.2
42	Merkato Tana	Ruwanda	7.3	1.6
43	Merkato Tana	Bole	8.7	1.6
44	Merkato Tana	Teklehaimanot	0.8	0.65
45	Merkato Tana	Ambasader	2.5	0.65
46	Merkato Tana	Meskel Adebaby	3.3	1.2
47	Merkato Tana	Filamingo	4.2	1.2
48	Merkato Tana	Bole Matemia Bet	5.8	1.2
49	Merkato Tana	Ruwanda	6.9	1.2
50	Merkato Tana	Bole	8.3	1.6
51	Merkato Raguel	Habite Giorgis Dildiy	0.6	0.65
52	Merkato Raguel	Giorgis Church	1.3	0.65
53	Merkato Raguel	Afincho Ber	3	1.2
54	Merkato Raguel	Menen School	3.7	1.2
55	Merkato Raguel	Shiro Meda	5.5	1.2
56	Merkato Raguel	Saniba Nekersa	6.9	1.2
57	Merkato Raguel	Qusquam	7.5	1.6
58	Merkato Mierab Hotel	Shawel Dema School	0.8	0.65
59	Merkato Mierab Hotel	Amanuel Church	1.6	0.65
60	Merkato Mierab Hotel	Koka Kola Adisu	3.6	1.2
61	Merkato Mierab Hotel	Amanuel	1.6	0.65
62	Merkato Mierab Hotel	Mesalemia	2.3	0.65
63	Merkato Raguel	Teklehaimanot	0.7	0.65
64	Merkato Raguel	Teyodros Adebabay	2.5	0.65
65	Merkato Raguel	Fit Ber	3.6	1.2
66	Merkato Raguel	Tiyit Bet	4.6	1.2
67	Merkato Raguel	Aware	5.4	1.2
68	Merkato Sinimaras	Teklehaymanot	0.7	0.65
69	Merkato Sinimaras	Tikur Anbessa Hopital	1.7	0.65
70	Merkato Sinimaras	Meksiko	3	1.2
71	Merkato Sinimaras	Tinbaho Monopl	3.9	1.2
72	Merkato Sinimaras	Mekanisa	7.5	1.6
73	Merkato Tana	Teklehamanot	0.7	0.65
74	Merkato Tana	Tikur Anbessa Hopital	1.7	0.65
75	Merkato Tana	Fil Wuha	2.9	1.2
76	Merkato Tana	Super Mrarket	4	1.2
77	Merkato Tana	Urael Church	5.4	1.2
78	Merkato Tana	Tele Medihanialem	7.3	1.6
79	Merkato Amede	Menahria	0.6	0.65
80	Merkato Amede	Kuas Meda	1.2	0.65

Route No	Start of Route	End of Route	Km	Tariff
81	Merkato Amede	Pasteur	2.5	0.65
82	Merkato Amede	Paulos Hospital	3	1.2
83	Merkato Ertirea Hotel	Gojam Berenda	0.6	0.65
84	Merkato Ertirea Hotel	Yohanis Church	1.8	0.65
85	Merkato Ertirea Hotel	Kelemework School	2.9	1.2
86	Merkato Ertirea Hotel	Kechene Medihanialem School	5.1	1.2
87	Merkato Ertirea Hotel	8 Kutir Matoria	5.1	1.2
88	Merkato Raguel	Afincho Ber	3	1.2
89	Merkato Raguel	Sidist Kilo	3.6	1.2
90	Merkato Raguel	Sostegna Shialeka	4.5	1.2
91	Merkato Raguel	Ferensay Enbasi	5.9	1.2
92	Merkato Tana	Chew Bernda	1.8	0.65
93	Merkato Tana	Pater Metatefia	2.7	1.2
94	Merkato Tana	Enkulal Fabrika	3.1	1.2
95	Merkato Tana	Polis Megenagna	3.7	1.2
96	Merkato Tana	Rufael Chrch	4.7	1.2
97	Mekato Mierab	Abinet	1.5	0.65
98	Mekato Mierab	Kefitegna Fird Bet	2.4	0.65
99	Mekato Mierab	Balcha Hospital	3.1	1.2
100	Mekato Mierab	Bnanna Shai Minister	4.1	1.2
101	Mekato Mierab	Sport Commition	4.9	1.2
102	Mekato Mierab	Abinet	1.5	0.65
103	Mekato Mierab	Adisu Koka Kola	2.5	0.65
104	Mekato Mierab	Torhayloch	3.3	1.2
105	Mekato Mierab	Keta Hulal Shel	3.7	1.2
106	Mekato Mierab	3 Kutir Matoria	5.7	1.2
107	Mekato Mierab	Zenebe Work Hospital	6.9	1.2
108	Mekato Mierab	Ayer Tena	8.2	1.6
109	Mekato Mierab	Samuna Factory	9.9	1.6
110	Mekato Mierab	Kara Kore	10.3	1.75
111	Merkato Amede	Menheria	0.8	0.65
112	Merkato Amede	Mesalemia	1.6	0.65
113	Merkato Amede	Kalef Dildiy	2.7	1.2
114	Merkato Amede	Atari Tera	3.8	1.2
115	Merkato Amede	Winget School	8.4	1.6
116	Merkato Amede	Adisu Micaïl	1.5	0.65
117	Merkato Amede	Pasteur	2.3	0.65
118	Merkato Amede	Medihanialem School	3.3	1.2
119	Merkato Amede	Birchiko Fabirika	6.4	1.2
120	Merkato Amede	Asko	7.9	1.6
121	Merkato Mierab	Habite Giorgis Dildiy	0.6	0.65
122	Merkato Mierab	Kulibi Medihanit Bet	1.5	0.65
123	Merkato Mierab	Degol Adebabay	2.1	0.65

Route No	Start of Route	End of Route	Km	Tariff
124	Merkato Raguel	Habite Giorgis Dildiy	0.6	0.65
125	Merkato Raguel	Giorgis Church	1.4	0.65
126	Merkato Raguel	Afincho Ber	3	1.2
127	Merkato Raguel	Yekatit 12 Hospital	3.6	1.2
128	Merkato Raguel	Minilik Hospital	5.3	1.2
129	Merkato Mierab	Habite Giorgis Dildiy	0.9	0.65
130	Merkato Mierab	Kulibi Medihanit Bet	1.5	0.65
131	Merkato Mierab	Degol Adebabay	2.1	0.65
132	Merkato Raguel	Habite Giorgis Dildiy	0.6	0.65
133	Merkato Raguel	Giorgis Church	1.4	0.65
134	Merkato Raguel	Afincho Ber	3	1.2
135	Merkato Raguel	Yekatit 12 Hospital	3.6	1.2
136	Merkato	Sebteгна	0.5	0.65
137	Merkato	Abinet	1.5	0.65
138	Merkato	Kefiteгна Firdbet	2.4	0.65
139	Merkato	Lieta	3	1.2
140	Merkato	Meksiko	3.6	1.2
141	Merkato	Awra Godana	3.8	1.2
142	Merkato	Mamo Cacha Garaje	4.6	1.2
143	Merkato Raguel	Minilik Hospital	5.3	1.2
144	Merkato	Kera	6.3	1.2
145	Kolfe Atena Tera	Chimad	1.4	0.65
146	Kolfe Atena Tera	Menahria	3.2	1.2
147	Kolfe Atena Tera	Abinet	4.8	1.2
148	Kolfe Atena Tera	Kefiteгна Firdbet	5.7	1.2
149	Kolfe Atena Tera	Chimad	1.4	0.65
150	Kolfe Atena Tera	Menaheria	3.2	1.2
151	Kolfe Atena Tera	Abinet	4.8	1.2
152	Kolfe Atena Tera	Kefiteгна Firdbet	5.7	1.2
153	Kolfe Atena Tera	Meksiko	6.8	1.2
154	Meksiko	Awragodana	0.2	0.65
155	Meksiko	Mamo Cacha Garaje	1	0.65
156	Meksiko	Kera	2.7	1.2
157	Meksiko	Ehil Gotera	3.9	1.2
158	Meksiko	Yosef Betekiristian	5.3	1.2
159	Meksiko	Adis Goma	7.7	1.6
160	Meksiko	Timbao	1.1	0.65
161	Meksiko	Ediget Tit Fabrica	2	0.65
162	Meksiko	Dil Gebeya	3.7	1.2
163	Meksiko	Kefiteгна 23 Clinic	4.3	1.2
164	Meksiko	Biherawi Teatre	0.6	0.65
165	Meksiko	Filwiha	1.4	0.65
166	Meksiko	Super Mrarket	2.3	0.65

Route No	Start of Route	End of Route	Km	Tariff
167	Meksiko	Kazanchis Total	2.9	1.2
168	Meksiko	Kefitegna Firdbet	1.1	0.65
169	Meksiko	Torhayloch	2.5	0.65
170	Meksiko	Holand	3.4	1.2
171	Meksiko	18 Kutir Autobis Mazoria	2.7	1.2
172	Meksiko	Atena Tera	7.7	1.6
173	Kera	Awragodana	2.5	0.65
174	Kera	Wabishebele	3	1.2
175	Kera	Biherawi Teiter	3.7	1.2
176	Kera	Tikur Anbesa School	4.4	1.2
177	Kera	Piassa	5.9	1.2
178	Mebrat Hail Gofa	Kera	2.8	1.2
179	Mebrat Hail Gofa	Mamo Cacha Garaje	4.5	1.2
180	Mebrat Hail Gofa	Fiat	4.9	1.2
181	Mebrat Hail Gofa	Awragodana	5.3	1.2
182	Mebrat Hail Gofa	Meksiko	5.5	1.2
183	Mekanisa	Tinbaho	3.6	1.2
184	Mekanisa	Meksiko	4.5	1.2
185	Mekanisa	Lideta	5.1	1.2
186	Mekanisa	Kefitegna Firdbet	5.7	1.2
187	Mekanisa	Abinet	6.6	1.2
188	Mekanisa	Merkato Mierab Hotel	8.1	1.6
189	Legehar	Meskel Adebaby	0.8	0.65
190	Legehar	Urael	2.4	0.65
191	Legehar	Wiha Limat	3.3	1.2
192	Legehar	22 Mazoria	4.1	1.2
193	Legehar	Megengna	5.6	1.2
194	Legehar	Lamberet	7.2	1.6
195	Legehar	Yerer Hotel	9.6	1.6
196	Legehar	Kotebe	10.9	1.75
197	Legehar	Kara	13.9	2.2
198	Biherwi Teater	Senga Tera	0.4	0.65
199	Biherwi Teater	Mecsico	1.2	0.65
200	Biherwi Teater	Lideta	1.8	0.65
201	Biherwi Teater	Kefitegna Firdbet	2.3	0.65
202	Biherwi Teater	Hinsta College	2.5	0.65
203	Biherwi Teater	Torhayloch	3.7	1.2
204	Biherwi Teater	Mecsico	1.2	0.65
205	Biherwi Teater	Kefitegna Fird Bet	2.5	0.65
206	Biherwi Teater	Torhayloch	3.9	1.2
207	Meskel Adebaby	Banbis	0.4	0.65
208	Meskel Adebaby	Urael	1.6	0.65
209	Meskel Adebaby	Tele	3.4	1.2

Route No	Start of Route	End of Route	Km	Tariff
210	Meskel Adebaby Gion	Tikur Anbessa School	1.3	0.65
211	Meskel Adebaby Gion	Degol Adebabay	2.7	1.2
212	Awtobis Tera	Mesgid	0.8	0.65
213	Awtobis Tera	Teklehaimanot	1.6	0.65
214	Awtobis Tera	Ager Astedaer	2.7	1.2
215	Awtobis Tera	Ambasader Teater	3.3	1.2
216	Awtobis Tera	Arategna Kifle Tor	4.6	1.2
217	Awtobis Tera	Hawi Hotel	6.3	1.2
218	Awtobis Tera	Gotera	7.5	1.6
219	Minilic Hospital	Ginfile Dildiy	1.2	0.65
220	Minilic Hospital	Arat Kolo	2	0.65
221	Minilic Hospital	Gebriel Mesalemia	3.4	1.2
222	Minilic Hospital	Kaznchis Total	4.5	1.2
223	Minilic Hospital	Sidist Kilo	1.5	0.65
224	Minilic Hospital	Dagimawiminilic School	2.6	1.2
225	Minilic Hospital	Birhaninaselam Matemia Bet	3.1	1.2
226	Minilic Hospital	Piassa	4.7	1.2
227	Minilic Hospital	Habiegiorgis Dildiy	6.2	1.2
228	Minilic Hospital	Gojam Berenda	6.7	1.2
229	Minilic Hospital	Autobis	7.2	1.6
230	Arat Kilo	Mismar Fabrika	1.2	0.65
231	Arat Kilo	Kenia Embassy	2.5	0.65
232	Arat Kilo	Woreda 16	4.2	1.2
233	Arat Kilo	Megengna Metatefia	4.9	1.2
234	Arat Kilo	Shola	6.6	1.2
235	Arat Kilo	Yerer Hotel	8.8	1.6
236	Arat Kilo	Kotebe	10	1.6
237	Arat Kilo	Piassa	2	0.65
238	Arat Kilo	Habite Giorgis Dildiy	3.2	1.2
239	Arat Kilo	Merkato Mierab Hotel	4.1	1.2
240	Bole	Ruwanda	2	0.65
241	Bole	Bole Matemia Bet	3	1.2
242	Bole	Flamingo	4.7	1.2
243	Bole	Africa Adarash	5.3	1.2
244	Bole	Gebriel Mesalemia	7	1.2
245	Bole	Arat Kolo	7.8	1.6
246	Bole	Sidist Kilo	9.3	1.6
247	Bole	Teferi Mokonnen	10.1	1.75
248	Bole	Shiro Meda	10.2	1.75
249	Wanaw Posta Bet	Meskel Adebaby	1.5	0.65
250	Wanaw Posta Bet	Bole Matemia Bet	3.6	1.2
251	Wanaw Posta Bet	Japan Embassy	5	1.2
252	Wanaw Posta Bet	Bole	6.8	1.2

Route No	Start of Route	End of Route	Km	Tariff
253	Stadium	Nazret Mekina Tera	0.7	0.65
254	Stadium	Tikur Anbessa Hopital	2	0.65
255	Stadium	Teklehaymanot Hospital	3	1.2
256	Stadium	Eslam Meskid	3.6	1.2
257	Stadium	Meksico	1.5	0.65
258	Stadium	Kiflehager Awtobis Tera	4.7	1.2
259	Gion Hotel	Ager Astedaer	1.3	0.65
260	Gion Hotel	Teklehamanot	2.5	0.65
261	Gion Hotel	Merkato Mierab Hotel	3.3	1.1
262	Legehar	Tena Tibeka	1.2	0.65
263	Legehar	Teklehaymanot	2.6	1.2
264	Legehar	Meskid	3.3	1.2
265	Legehar	Awtobistera	4.4	1.2
266	Sport Commition	Meskerem Buna Bet	1.6	0.65
267	Sport Commition	Hawi Hotel	2.9	1.2
268	Sport Commition	Ehil Gotera	4	1.2
269	Sport Commition	Adey Abeba Tit Fabrica	6.9	1.2
270	Sport Commition	Saris	7.2	1.6
271	Meslemia	Shewa Dabo	1.5	0.65
272	Meslemia	Habtegiogis Dildiy	2.1	0.65
273	Damo Hotel	Kebele 58(Hana Mariam)	1.7	0.65
274	Total Megenteya	Adisu Meoria Sefer	1.2	0.65
275	Welo Sefer	Ehil Gotera	2.2	0.65
276	Abinet	Teklehaymanot	1.3	0.65
277	Abinet	Piassa	2.8	1.2
278	Piassa	Torhayloch	6.2	1.2
279	Piassa	Tewodros Debabay	0.9	0.65
280	Piassa	Posta Bet	1.5	0.65
281	Piassa	Biherawi Theater	2.2	0.65
282	Piassa	Meksico	3.5	1.2
283	Piassa	Lideta	4	1.2
284	Piassa	Kefitegna Fird Bet	4.6	1.2
285	Piassa	Habtegiogis Dildiy	1.2	0.65
286	Piassa	Menaheria	2.4	0.65
287	Piassa	Msalemia	2.6	1.2
288	Piassa	Yohanis Church	1.6	0.65
289	Piassa	Meonnenoch Kibeb(Polis)	2.5	0.65
290	Piassa	Addis Ababa School	3.1	1.2
291	Piassa	Pasteur	3.8	1.2
292	Piassa	Semen Hotel	1.4	0.65
293	Piassa	Kechene Mazoria	1.6	0.65
294	Piassa	Wereda 10 Pois Tabia	2.5	0.65
295	Piassa	Adissu Gebeya	3	1.2

Route No	Start of Route	End of Route	Km	Tariff
296	Piassa	Total	3.8	1.2
297	Piassa	Dil Ber Hotel	4.8	1.2
298	Piassa	Arat Kilo Wewekima	2.4	0.65
299	Piassa	Mismar Fabrika	4.1	1.2
300	Piassa	Kokebe Tsibah School	4.9	1.2
301	Piassa	Engliz Embassy	5.8	1.2
302	Piassa	Wereda 16 Tsihifet Bet	7	1.2
303	Piassa	Megenagna	7.8	1.6
304	Piassa	Teyodros Adebabay	1	0.65
305	Piassa	Posta Bet	1.4	0.65
306	Piassa	Biherawi Teiter	2.1	0.65
307	Piassa	Arat Kilo Timihirt Minister	2	0.65
308	Piassa	Fit Ber	3.4	1.2
309	Piassa	Kazanchis	4.7	1.2
310	Piassa	Urael	5.4	1.2
311	Piassa	Legehar	2.8	1.2
312	Arat Kilo	Gebriel Mesalemia	1.2	0.65
313	Arat Kilo	Wtchi Gudy Minister	1.5	0.65
314	Arat Kilo Timihirt Minister Biro	Tyit Bet	0.8	0.65
315	Arat Kilo Timihirt Minister Biro	Tegibreed School	3.7	1.2
316	Arat Kilo Timihirt Minister Biro	Cazanchis	1.6	0.65
317	Arat Kilo	Estifanos Chruch	2.4	0.65
318	Arat Kilo	Sport Commition	3.2	1.2
319	Arat Kilo	Mecsico	4.4	1.2
320	Megegna	Emperial Hotel	2	0.65
321	Megegna	Moinco	3	1.2
322	Megegna	Bole	3.9	1.2
323	Megegna	Anbssa Ketma Awtobis Metatefia	1.2	0.65
324	Megegna	Mebrat Hail Gergi	2.3	0.65
325	Megegna	Emperial Hotel	2	0.65
326	Megegna	Gergi Bole	3.5	1.2
327	Megegna	Elca Metatefia	1.4	0.65
328	Megegna	Gurdi Shola	2.2	0.65
329	Megegna	Altad	4.4	1.2
330	Megegna	Behind Amiche	0.9	0.65
331	Megegna	Egziabher Ab Betecristian	1.3	0.65
332	Megegna	Kebele 24 Tshifet Bet	1.3	0.65
333	Megegna	22 Mazonia	1.4	0.65
334	Megegna	Urael Church	2.8	1.2

Route No	Start of Route	End of Route	Km	Tariff
335	Megegna	Gibrina Minister	3.3	1.2
336	Megegna	Fil Wuha	5	1.2
337	Megegna	Tikur Anbesa Hospital	6.3	1.2
338	Megegna	Teklehaymanot	7.2	1.6
339	Megegna	Merkato Mierab Hotel	8.1	1.6
340	Torhailoch	Keraniyo Dildiy	1.9	0.65
341	Torhailoch	Keraniyo Church	2.5	0.65
342	Torhailoch	Weybul Mariam	4.4	1.2
343	Ambassador Teater	Nigd Matemia Bet	1.2	0.65
344	Ambassador Teater	Arat Kilo Turist Hotel	2.3	0.65
345	Shiro Meda	Kidane Mihret Dildiy	1.1	0.65
346	Shiro Meda	Kidane Mihret Church	2.5	0.65
347	Asko	Sansli	1.4	0.65
348	Asko	Shekla Fabrica	2	0.65
349	Asko	Burayu	4.4	1.2
350	Asko	Burayu Mariam	6.4	1.2
351	Kara Kore	Welte Suk	1.7	0.65
352	Kara Kore	Polis Elma Masetegna	4.6	1.2
353	Kara Kore	Alem Gena	6.6	1.2
354	Kara Kore	Alem Gena Michael	7.9	1.6
355	Kara Kore	Asa Erbata	10.4	1.75
356	Kara Kore	Sebeta	11.7	1.75
357	Kality	Akaki Cherkachek	2.4	0.65
358	Kality	Akaki Dildiy	3	1.2
359	Kality	Dventist Mishin	3.4	1.2
360	Kality	Nigd Bank	4	1.2
361	Ruwanda	Ayer Amba Hotel	0.8	0.65
362	Ruwanda	Bole Michail	1.4	0.65
363	Kazanchis	Gebriel Mesalemia	1.1	0.65
364	Kazanchis	Minilik School	1.8	0.65
365	Megenagna	Wefcho Bet	2.8	1.2
366	Megenagna	Gergi Giorgis Mesalemia	3.4	1.2
367	Megenagna	Gergi Diborah School	2.5	0.65
368	Megenagna	Gergi Taxi Tra	3.3	1.2
369	Megenagna	Shlite Mihret	2.5	0.6
370	Megenagna	Cmc	4.5	1.2
371	Cmc	Meri	2.1	0.65
372	Cmc	Gurdi Shola	2.5	0.65
373	Megenagna Taxi Tera	Wered 16 Polis Tabia	1.5	0.65
374	Megenagna Chaf	Wered 16 Polis Tabia	0.7	0.65
375	Megenagna Taxi Tera	Engliz Embassy	2.5	0.65
376	Megenagna Chaf	Engliz Embassy	1.7	0.65
377	Megenagna Taxi Tera	Kenia Embassy	3	1.2

Route No	Start of Route	End of Route	Km	Tariff
378	Megenagna Chaf	Kenia Embassy	2.2	0.65
379	Megenagna Taxi Tera	Kokebe Tsibah School	3.4	1.2
380	Megenagna Chaf	Kokebe Tsibah School	2.6	1.2
381	Megenagna Taxi Tera	Kebena Didldiy	3.5	1.2
382	Megenagna Chaf	Kebena Didldiy	2.7	1.2
383	Megenagna Taxi Tera	Kebena Shell	3.7	1.2
384	Megenagna Chaf	Kebena Shell	2.9	1.2
385	Megenagna Taxi Tera	Mismar Fabrika	4.1	1.2
386	Megenagna Chaf	Mismar Fabrika	3.3	1.2
387	Megenagna Taxi Tera	Rasamba Hotel	4.4	1.2
388	Megenagna Chaf	Rasamba Hotel	3.6	1.2
389	Megenagna Taxi Tera	Ginfile	5	1.2
390	Megenagna Chaf	Ginfile	4.2	1.2
391	Megenagna Taxi Tera	Mahiberawi Wstina	5.2	1.2
392	Megenagna Chaf	Mahiberawi Wstina	4.4	1.2
393	Megenagna Taxi Tera	Arat Kila University	5.4	1.2
394	Megenagna Chaf	Arat Kila University	4.6	1.2
395	Megenagna Taxi Tera	Turist Hotel	5.7	1.2
396	Megenagna Chaf	Turist Hotel	4.9	1.2
397	Megenagna Taxi Tera	Ras Mekonnen Dildiy	6.5	1.2
398	Megenagna Chaf	Ras Mekonnen Dildiy	5.7	1.2
399	Megenagna Taxi Tera	Grick Church	7	1.2
400	Megenagna Chaf	Grick Church	6.2	1.2
401	Megenagna Taxi Tera	Sinima Empayer	7.4	1.2
402	Megenagna Chaf	Sinima Empayer	6.6	1.2
403	Urael Church	22 Mazonia	1.4	0.65
404	Urael Church	Lem Hotel	2.2	0.65
405	Urael Church	Megenagna Mizan Tabia	2.6	1.2
406	Urael Church	Megenagna Taxi Tera	3.2	1.2
407	Megenagna Taxi Tera	Zerfeshiwal Txi Mechagnia	0.7	0.65
408	Megenagna Taxi Tera	Gurdi Shola	2.5	0.65
409	Zerfeshiwal Txi Mechagnia	Gurdi Shola	1.8	0.65
410	Megenagna Taxi Tera	Ethiopia Management Institute	3.3	1.2
411	Zerfeshiwal Txi Mechagnia	Ethiopia Management Institute	2.6	1.2
412	Megenagna Taxi Tera	Civil Sevice	3.8	1.2
413	Zerfeshiwal Txi Mechagnia	Civil Sevice	3.1	1.2
414	Megenagna Taxi Tera	Michael	4.6	1.2
415	Zerfeshiwal Txi Mechagnia	Michael	3.9	1.2
416	Megenagna Taxi Tera	Cmc	5.4	1.2
417	Zerfeshiwal Txi Mechagnia	Cmc	4.7	1.2
418	Megenagna Taxi Tera	Semit Megenteya	5.9	1.2
419	Zerfeshiwal Txi Mechagnia	Semit Megenteya	5.2	1.2
420	Megenagna Taxi Tera	Semit Fabrika Taxi Mazonia	7.9	1.6

Route No	Start of Route	End of Route	Km	Tariff
421	Zerfeshiwal Txi Mechagnia	Semit Fabrica Taxi Mazoria	7.2	1.6
422	Semit Megenteya	Semit Fabrica Taxi Mazoria	2	0.65
423	Megenagna Taxi Tera	Meri	6.8	1.2
424	Zerfeshiwal Txi Mechagnia	Meri	6.1	1.2
425	Megenagna Taxi Tera	Ayat	7.9	1.6
426	Zerfeshiwal Txi Mechagnia	Ayat	7.1	1.6
427	Ayat Taxi Mazoria	Semit Megenteya	2	0.65
428	Ayat Taxi Mazoria	Michael	3.3	1.3
429	Ayat Taxi Mazoria	Civil Sevice	4	1.2
430	Ayat Taxi Mazoria	Ethiopia Management Institute	4.5	1.2
431	Ayat Taxi Mazoria	Gurdi Shola	5.3	1.2
432	Ayat Taxi Mazoria	Zerfeshiwal School	7.2	1.6

Source: Addis Ababa transport Branch office.

APPENDIX E

LONCHINA ROUTE INFORMATION

Route No	Start	Via	Terminal	No Of Buss On The Route	Tariff	Km
1	Piassa	Nifas Silk	Saris Abo	6	1.5	10.5
2	Piassa	Ambasader	Bole Airport	4	1.1	8.6
3	Piassa	Sport Commination	Bole Airport	4	1.1	8.8
4	Piassa	Mexico	Gofa Mebrat Hail	5	1.5	10.6
5	Piassa		Asko	8	1.1	9.8
6	Piassa		Total 3 Kutir Mazoria	4	1.1	8.8
7	Piassa		Karakore	8	1.5	13.4
8	Piassa	Kebena	Kotebe	6	1.1	13.4
9	Piassa		Dilber/Gogam Ber	6	0.75	8.6
10	Piassa	Kazanchis	Megenagna	5	0.75	8.7
11	Bihrawi Teater	Ayertena	Karakore	6	1.5	13.3
12	Bihrawi Teater	Kera	Gofa Mebrat Hail	7	0.75	8.1
13	Bihrawi Teater	Mexico	Saris Abo Mazoria	4	1.1	9.5
14	Bihrawi Teater	Mexico	Kelem Fabrica(3kutir Mazoia)	4	0.75	7.5
15	Bihrawi Teater	Mexico	Mekanisa	4	0.75	7.5
16	Ayer Tena	Bisrate Gebriel	Saris Abo	8	1.5	13.4
17	Merkato	Abinet	Saris Abo Mazoria	4	1.5	12.8
18	Merkato		Ferensay Legasion	4	1.1	6.5
19	Merkato	Arat Kilo	Bela	6	1.1	9.1
20	Merkato	Giorgis	Minilik Hospital	4	0.75	5.6
21	Merkato	Adisu Michael	Asko	6	1.1	9.3
22	Merkato	Sefere Selam	Asko	6	1.1	9.1
23	Merkato	Koka Kola Febrica	Alem Bank	8	1.1	11.2
24	Merkato	Sebategna	Betel Hospital	4	1.1	10.2
25	Merkato	Teklehaymanot	Saris Adisu Sefer	4	1.5	13.2
26	Merkato	Mexico	Lafto	4	1.5	10.3
27	Merkato		Kuskaum	6	1.5	11.5
28	Merkato		Eyesus	6	1.1	12.5
29	Merkato		Gergi	4	1.5	13.4
30	Merkato		Gurd Shola	4	1.5	11.8
31	Merkato		Kidane Mihret	6	0.5	6.1

Route No	Start	Via	Terminal	No Of Buss On The Route	Tariff	Km
32	Merkato	Abinet Hotel	3 Kutir Mazoria	6	1.1	9.1
33	Merkato	3 Kutir Mazoria	Ayer Tena	8	1.1	10.2
34	Merkato	3 Kutir Mazoria	Kara Kore	16	1.5	13.2
35	Merkato		Sebeta	4	2	14.5
36	Adis Ketema	Merkato	Atena Tera	10	0.75	6.5
37	Sidist Kilo	Arat Kilo, Megengna	Cmc	4	1.1	11.6
38	Shiro Meda	Sidist Kilo, Meskel Adebaby	Bole	4	1.1	8.6
39	Sidist Kilo	Megenagna	Kotebe	6	1.1	12.7
40	Legehar	Megenagna	Gergi	4	1.1	9.5
41	Legehar	Mexico	Mekanisa	5	0.75	7
42	Legehar	Saris	Kality	5	1.5	12.5
43	Legehar	Megenagna	Kara	5	1.1	14.3
44	Legehar	Ruwanda	Bole Michael	4	0.75	5.8
45	Legehar	Mexico	Alembank	4	1.1	8.1
46	Legehar	Arategna Kifle Tor	Saris Abo Adisu Sefer	4	1.1	9.1
47	Legehar	Mexico	Betel Hospital	4	1.1	10.2
48	Legehar	Mexico Gofa	Lafto	4	1.1	7.9
49	Legehar		Shiro Meda	4	1.1	7.2
51	Shiro Meda		Kolfe Fetnoderash	4	1.1	14.1
52	Arat Kilo	Megenagna	Gergi	4	1.1	9.2
53	Arat Kilo	Megenagna	Yerer Ber	4	1.1	11.1
54	Arat Kilo	Megenagna	Kara	6	1.5	13.5
55	Arat Kilo	Megenagna	Cmc	4	1	12.8
56	Kazanchis	Kiray Betoh- Megenagna	Gergi	4	1.1	8.5
57	Kazanchis	Urael- Megenagna- Amiche	Gergi	4	1.1	8.2
58	Kazanchis	Mexico	Ayer Tena	4	1.5	11.1
59	Kolfe	Kelebet Menged	Ayer Tena	4	1.75	13.2
60	Kefitegna Fird Bet	Sport Commition	Megenagna	4	1.1	7.9
61	Balcha		Minilik Adebabay	4	1.1	7.8
62	Adisu Gebeya	Mexico	Kera	4	1.1	9.7
63	Megenagna	Bole-Welosefer- Gotera	Saris Abo	4	1.65	12.8
64	Merkato		Sululta	6	2	15.4
65	Adisu Gebeya		Sululta	6	2	16.2

Route No	Start	Via	Terminal	No Of Buss On The Route	Tariff	Km
66	Megenagna	Kelebet Menged	Saris Abo	14	1	11.1
67	Mebrat Hail	Gegi 46 Kutir Mazoria	Bole-Mexico	4	1.1	11.5
68	Mebrat Hail		Gergi-Sefera	4	0.5	5.2
69	Samit Leslasa Fabrica	Cmc-Megenagna	Legehar	6	1.25	13.9
70	Ayat Mazoria		Megenagna	6	1.1	8.1
71	Kara	Megenagna	Arat Kilo	6	1.1	13.8
72	Mexico	Kazanchis-Bel Air	Shola Gebeya	4	1.1	9.4
73	Shola Gebeya	Urael-Kazanchis	Piassa	4	1.1	8.3
74	Mebrat Hail	Bole	Mexico	4	1.1	11.5
75	Megenagna		Mebrat Hail	6	0.5	4.4
76	Arat Kilo	Stadium	Legehar	4	0.5	3.9
77	Kazanchis	22 Mazoria	Tele	4	0.5	4.5
78	Kazanchis	Urael	Tele	4	0.5	3.2
79	Megenagna	22 Mazoria-Filwuha	Merkato	6	1.1	8.8
80	Megenagna		Stadium	10	0.5	5.3
81	Shola Gebeya	22 Mazoria	Stadium	4	0.5	5.5
82	Arat Kilo		Stadium	4	0.5	3.9
83	Megenagna	Kazanchis-Posta Bet	Merkato	6	1.1	6.5
84	Megenagna	Shola Gebeya-Arat Kilo	Piassa	6	1.1	7.1
85	Piassa	Afincho Ber	Minilik Hospital	6	0.5	3.8
86	Fetno Derash		Adis Ketama	10	0.75	8.1
87	Semen Gebeya		Adis Ketama	6	0.5	6.2
88	Ferensay Film Meakel		Adis Ketama	6	0.5	5.8
89	Cherkos	Stadium	Adis Ketama Meslemia	6	1.1	9.7
90	Legehar	Piassa	Dilber	6	1.1	10.1
91	Legehar	Sidist Kilo	Ferensay Kela	6	1.1	9.2
92	Legehar	Piassa	Winget School	4	0.75	8.8
93	Sidist Kilo	Mexico	Kera	6	1.25	12.3
94	Semen Gebeya/Adisu Gebeya	Piassa	Megenagna	6	1.25	10.9
95	Megenagna	Mebrat Hail-Yerer Ber	Sefera	6	1.1	10.4

Source: Addis Ababa transport Branch office.